Highway 22/90 Freestanding Emergency Department
MASTER SPECIFICATIONS

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SECTION 210517

SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40 – PVC Pipe shall not be installed in rated walls.

E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Interior Partitions:

a. Piping Smaller Than NPS 6 Galvanized-steel-pipe sleeves.

END OF SECTION 210517

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SECTION 210518

ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated finish.

B. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.

C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish.

D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel or brass with polished, chrome-plated finish and spring-clip fasteners.

E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed or exposed-rivet hinge; and spring-clip fasteners.

2.2 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.

b. Chrome-Plated Piping: One-piece steel, cast brass or split-plate steel with polished, chrome-plated finish.

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.

d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.

e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.

f. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.

g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.

h. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stainless steel with polished stainless-steel finish.

i. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.

j. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.

k. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.

l. Bare Piping in Unfinished Service Spaces: One-piece cast brass with polished, chrome-plated finish.

m. Bare Piping in Unfinished Service Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.

n. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.

o. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.

p. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 210518

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SECTION 210523

GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Two-piece ball valves with indicators.
2. Bronze butterfly valves with indicators.
3. Iron butterfly valves with indicators.
4. Check valves.
5. Trim and drain valves.

1.3 DEFINITIONS

A. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

B. NRS: Nonrising stem.

C. OS&Y: Outside screw and yoke.

D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and weld ends.
3. Set valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
   1. Main Level: HAMV - Fire Main Equipment.
      a. Level 1: HCBZ - Indicator Posts, Gate Valve.
      b. Level 1: HLOT - Valves.
         1) Level 3: HLUG - Ball Valves, System Control.
         2) Level 3: HLXS - Butterfly Valves.
         3) Level 3: HMER - Check Valves.
         4) Level 3: HMRZ - Gate Valves.
   2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.
      a. Level 1: VQGU - Valves, Trim and Drain.

B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:
   1. Automated Sprinkler Systems:
      a. Valves.
         1) Gate valves.
         2) Check valves.
            a) Single check valves.
         3) Miscellaneous valves.

C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.

D. ASME Compliance:
   1. ASME B16.1 for flanges on iron valves.
   2. ASME B1.20.1 for threads for threaded-end valves.
   3. ASME B31.9 for building services piping valves.

E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

F. NFPA Compliance: Comply with NFPA 24 for valves.

G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.

H. Valve Sizes: Same as upstream piping unless otherwise indicated.

I. Valve Actuator Types:
   1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
   2. Handwheel: For other than quarter-turn trim and drain valves.

3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

A. As manufactured by Nibco or Victaulic.

B. Description:

1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
2. Minimum Pressure Rating: 175 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear or traveling nut.
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.3 BRONZE BUTTERFLY VALVES WITH INDICATORS

A. As manufactured by Fivalco, Globe Fire Sprinkler, or Milwaukee Valve.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
2. Minimum: Pressure rating: 175 psig.
3. Body Material: Bronze.
4. Seat Material: EPDM.
5. Stem Material: Bronze or stainless steel.
6. Disc: Bronze with EPDM coating.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Ends Connections for Valves NPS 1 through NPS 2: Threaded ends.
10. Ends Connections for Valves NPS 2-1/2: Grooved ends.

2.4 IRON BUTTERFLY VALVES WITH INDICATORS

A. As manufactured by Fivalco, Globe Fire Sprinkler, or Victaulic.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, nickel plated and EPDM or SBR coated.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Body Design: Grooved-end connections.

2.5 CHECK VALVES

A. As manufactured by Fivalco, Globe Fire Sprinkler, or Victaulic.

B. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig.
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.6 TRIM AND DRAIN VALVES

A. Ball Valves:

1. As manufactured by Conbraco, Milwaukee Valve, or Victaulic.
2. Description:
   a. Pressure Rating: 175 psig.
   b. Body Design: Two piece.
   c. Body Material: Forged brass or bronze.
   d. Port size: Full or standard.
   e. Seats: PTFE.
   f. Stem: Bronze or stainless steel.
   g. Ball: Chrome-plated brass.
   h. Actuator: Handlever.
   i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.

j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Angle Valves:

1. As manufactured by Conbraco, Globe Fire Sprinkler, Victaulic, or approved equal.
2. Description:
   a. Pressure Rating: 175 psig.
   b. Body Material: Brass or bronze.
   c. Ends: Threaded.
   d. Stem: Bronze.
   e. Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:

1. As manufactured by Conbraco, Nibco, or United Brass Works.
2. Description:
   a. Pressure Rating: 175 psig.
   b. Body Material: Bronze with integral seat and screw-in bonnet.
   c. Ends: Threaded.
   d. Stem: Bronze.
   e. Disc Holder and Nut: Bronze.
   f. Disc Seat: Nitrile.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

A. Comply with requirements in the following Sections for specific valve installation requirements and applications:

1. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the pipe center.

F. Install valves in position to allow full stem movement.

G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.

I. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 210523

SECTION 210529

HANGERS AND SUPPORTS FOR FIRE SUPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal hanger-shield inserts.
5. Fastener systems.
6. Equipment supports.

B. Related Requirements:

1. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for vibration isolation devices.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

B. NFPA Compliance: Comply with NFPA 13.

C. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.3 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: NFPA-approved, UL-listed, or FM-approved threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or Stainless steel.

2.4 EQUIPMENT SUPPORTS

A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.5 MATERIALS

A. Aluminum: ASTM B 221.

B. Carbon Steel: ASTM A 1011/A 1011M.

C. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A 240/A 240M.

E. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout, suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.

2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Install in accordance with approvals and listings.

2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

C. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

D. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

E. Install lateral bracing with pipe hangers and supports to prevent swaying.

F. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger

and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

G. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

H. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.3 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.4 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099123 "Interior Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.5 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with NFPA requirements for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.

3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

F. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

G. Hanger-Rod Attachments: Comply with NFPA requirements.

H. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. C-Clamps (MSS Type 23): For structural shapes.
3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

I. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 210529

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SECTION 210548

VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric hangers.
2. Snubbers.
3. Restraint channel bracings.
4. Seismic-restraint accessories.
5. Mechanical anchor bolts.

B. Related Requirements:

1. Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
B. Qualification Data: For professional engineer.
C. Welding certificates.
D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval

by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Seismic design category as Defined in the IBC: D.
2. Design Spectral Response Acceleration at Short Periods 1.50 g.
3. Design Spectral Response Acceleration at 1.0-Second Period: 0.60 g.

2.2 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post-and-sleeve arrangement separated by a minimum 1/2-inch-thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.3 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.4 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.5 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Reinforcing steel angle clamped to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.

C. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.6 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES that provides required submittals for component.

B. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211313 "Wet-Pipe Sprinkler Systems" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

END OF SECTION 210548

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SECTION 210553

IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipe labels.
2. Stencils.
3. Valve tags.
4. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.

D. Valve Schedules: Valve numbering scheme.

PART 2 - PRODUCTS

2.1 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

E. Pipe-Label Colors:

1. Background Color: Safety Red.
2. Letter Color: White.

2.3 STENCILS

A. Stencils for Piping:

1. Lettering Size: Size letters according to ASME A13.1 for piping
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Safety Red, exterior, gloss, acrylic enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: White, exterior, acrylic enamel. Paint may be in pressurized spray-can form.

2.4 VALVE TAGS

A. Description: Stamped or engraved with 1/4-inch letters for piping-system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032 inch aluminum, 0.032 inch or anodized aluminum, 0.032 inch thick, with predrilled holes for attachment hardware.
2. Fasteners: Brass wire-link chain, beaded chain or S-hook.
3. Valve-Tag Color: Safety Red.
4. Letter Color: White.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

A. Description: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 PIPE LABEL INSTALLATION

A. Piping: Painting of piping is specified in Section 099123 "Interior Painting."

B. Stenciled Pipe-Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit a view of concealed piping.

5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:

1. Valve-Tag Size and Shape:
   a. Wet-Pipe Sprinkler System: 1-1/2 inches, round.

3.5 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 210553

SECTION 211000

WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-suppression piping, fittings, and appurtenances.
2. Fire department connections.
3. System control valves.
4. Dry-sprinkler system nitrogen generator with purge/vent.
5. Fire-suppression piping specialties.
6. Cover systems for sprinkler piping.
7. Sprinklers.
8. Alarm devices.
9. Pressure gauges.

B. Related Requirements

1.2 DEFINITIONS

A. Standard-Pressure Fire-Suppression System Piping: Piping designed to operate at working pressure of 175 psig maximum.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
   a. Include construction details, material descriptions, dimensions of individual components and profiles.
   b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Prepare in accordance with NFPA 13 section "Working Plans."
   a. Include plans, elevations, and sections of the system piping and details.
   b. Include detailed riser diagram and schematic diagram showing system supply, supply connection, devices, valves, pipe and fittings, as well as the delineation of the standard-pressure and high-pressure portions of the fire-suppression system.
2. Prepare computer-generated hydraulic calculations in accordance with the following:
   a. Minimum operating pressure at hydraulically most remote fire hose valve is to be 100 psig.
   b. Name of hydraulic program used.

c. Water supply information, including fire hydrant flow test data report.

3. Submit documents and calculations signed and sealed by qualified professional engineer responsible for their preparation or NICET Level IV certified-technician submittals are to include the following information on each drawing title block: technician's name, NICET certification number, and NICET certification specialty area and level.
4. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For fire-suppression systems indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation or prepared by NICET Level IV-certified technician, Water-Based Systems Layout.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fire-suppression system plans and sections, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Seismic Qualification Certificates: For fire-suppression equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Qualification Data: For qualified Installer and professional engineer or NICET-IV certified technician.

D. Design Data: Approved fire-suppression piping working plans, prepared in accordance with NFPA 13, including documented approval by AHJs, and including hydraulic calculations if applicable.

E. Welding certificates.

F. Field Test Reports:

1. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
2. Fire-hydrant flow test report.

G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-suppression systems and specialties to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by qualified professional engineer. NICET Level IV-certified technician, Water-Based Systems Layout.

B. Welding Qualifications: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code.

1.8 FIELD CONDITIONS

A. Interruption of Existing Fire-Suppression Service: Do not interrupt fire-suppression service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fire-suppression service in accordance with requirements indicated:

1. Notify Architect, Construction Manager or Owner no fewer than seven days in advance of proposed interruption of fire-suppression service.
2. Do not proceed with interruption of fire-suppression service without Architect's, Construction Manager's or Owner's written permission.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Automatic wet-pipe sprinkler system.

B. Automatic dry-pipe sprinkler.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-suppression system piping to withstand the effects of earthquake motions determined in accordance with NFPA 13. See Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

B. Fire-Suppression System Components, Devices, and Accessories: Listed in ULSE's "Fire Protection Equipment Directory" and FM Approvals' "Approval Guide."

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

D. Fire-suppression system equipment, specialties, accessories, installation, and testing to comply with NFPA 13.

E. Standard-Pressure Piping System Component: Listed for 175 psig minimum working pressure.

F. Delegated Design: Engage a qualified professional engineer or NICET Level IV-certified technician, "Water-Based Systems Layout to design fire-suppression systems.

1. Fire-Hydrant Flow Test:
    a. Available fire-hydrant flow test records indicate the following conditions:
        1) See drawings
    b. Perform fire-hydrant flow test and record the following conditions:
        1) Date:
        2) Time:
        3) Performed by:
        4) Location of Fire Hydrant:
        5) Static and Residual Pressure at Fire Hydrant:
        6) Measured Flow at Flow Fire Hydrant.
2. Margin of Safety for Available Water Flow and Pressure: 10percent, including losses through water-service piping, valves, and backflow preventers.
3. Sprinkler Occupancy Hazard Classifications:
    a. Electrical Equipment Rooms: Ordinary Hazard, Group 1
    b. General Storage Areas: Ordinary Hazard, Group 1
    c. Hospitals, including Animal Hospitals and Veterinary Facilities: Light Hazard
    d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1
    e. Offices, including Data Processing: Light Hazard
4. Minimum Density for Automatic-Sprinkler Piping Design:
    a. Light-Hazard Occupancy: 0.10 gpm/sq. ft. over 1500 sq. ft.
    b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm/sq. ft. over 1500 sq. ft.
    c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm/sq. ft. over 1500 sq. ft.

d. Special Occupancy Hazard: As determined by AHJs.

5. Maximum protection area per sprinkler in accordance with ULSE listing.
6. Maximum Protection Area per Sprinkler:
   a. Office Spaces: 225 sq. ft..
   b. Storage Areas: 130 sq. ft.
   c. Mechanical Equipment Rooms: 130 sq. ft.
   d. Electrical Equipment Rooms: 130 sq. ft.
   e. Other Areas: In accordance with NFPA 13 recommendations unless otherwise indicated.

G. Obtain documented approval of fire-suppression system design from AHJs.

2.3 FIRE-SUPPRESSION PIPING, FITTINGS, AND APPURTENANCES

A. Steel Pipe, Fittings, and Appurtenances:

1. Schedule 40 Steel Pipe: Black-steel pipe, ASTM A53/A53M, ASTM A135/A135M, or ASTM A795/A795M.
   a. Standards:
      1) UL 852.
      2) FM 1630.
   b. Factory-applied exterior coating.
   c. Factory-applied bacterial-resistant internal coating to reduce microbiologically influenced corrosion.
   d. Pipe ends may be factory or field formed to match joining method.
2. Schedule 10 Steel Pipe: Black-steel pipe, ASTM A53/A53M, ASTM A135/A135M, or ASTM A795/A795M.
   a. Standards:
      1) UL 852.
      2) FM 1630.
   b. Factory-applied exterior coating.
   c. Factory-applied bacterial resistant internal coating to reduce microbiologically influenced corrosion.
   d. Pipe ends may be factory or field formed to match joining method.
3. Engineered Light-Wall Steel Pipe: Black-steel pipe, ASTM A135/A135M or ASTM A795/A795M with wall thickness less than Schedule 40. Outside dimension is to be equivalent to Schedule 40.
   a. Standards:
      1) UL 852.

2) FM 1630.

b. Factory-applied exterior coating.

c. Factory-applied bacterial-resistant internal coating to reduce microbiologically influenced corrosion.

d. Pipe ends may be factory or field formed to match joining method.

4. Steel Pipe Nipples: Black steel, ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.
5. Steel Couplings: Uncoated steel, ASTM A865/A865M, threaded.
6. Gray-Iron Threaded Fittings: Uncoated gray-iron threaded fittings, ASME B16.4, Class 125, standard pattern.
7. Malleable- or Ductile-Iron Unions: ASME B16.3.
8. Cast-Iron Flanges: ASME B16.1, Class 125.
9. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
   a. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
      1) Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
      2) Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
   b. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1 carbon steel unless otherwise indicated.
10. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.
    a. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
11. Plain-End-Pipe Fittings:
    a. Pressure Rating: 175 psig minimum.
    b. Plain-End Fittings for Steel Piping: Uncoated plain-end fittings, ASTM A53/A53M, carbon steel or ASTM A106/A106M, forged steel with dimensions matching steel pipe.
    c. Plain-End-Pipe Couplings for Steel Piping: Rigid pattern for steel-pipe dimensions, ductile-iron or malleable-iron housing. Include EPDM-rubber gasket, and bolts and nuts.
12. Grooved-Joint, Steel-Pipe Appurtenances:
    a. Pressure Rating: 175 psig minimum.
    b. Grooved-End Fittings for Steel Piping: Uncoated grooved-end fittings, ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.

c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

13. Carbon Steel Pressure-Seal Fittings: UL 213, FM Approvals-approved, 175 psig pressure rating with carbon steel-, zinc-nickel-coated housing, EDPM O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

2.4 FIRE DEPARTMENT CONNECTIONS

A. Fire Department Connection, Exposed Type:

1. Standard: UL 405.
2. Description: Exposed, projecting, for wall mounting.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Corrosion-resistant metal.
5. Inlets: Brass with threads in accordance with NFPA 1963 and matching local fire department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
6. Caps: Brass, lugged type, with gasket and chain.
7. Escutcheon Plate: Round, brass, wall type.
8. Outlet: Back, with pipe threads.
9. Number of Inlets: Two.
10. Escutcheon Plate Marking: AUTO SPKR & STANDPIPE
11. Finish: Rough brass or bronze.
12. Outlet Size: NPS 4 (DN 100)

2.5 HOSE CONNECTIONS AND HOSE STATIONS - NOT USED

2.6 SYSTEM CONTROL VALVES

A. Listed in ULSE's "Fire Protection Equipment Directory" or FM Approvals' "Approval Guide."

B. Pressure Rating:

1. Standard-Pressure Piping Valves: 175 psig minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. System Control Valve, Alarm Valve:

1. Standard: UL 193.
2. Design: For horizontal or vertical installation.
3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, and fill-line attachment with strainer.

4. Drip cup assembly pipe drain without valves and separate from main drain piping with check valve to main drain piping.

G. System Control Valve, Dry-Pipe Valve:

1. Standards:
   a. UL 260.
   b. UL 1486.
2. Design: Differential-pressure type.
3. Include quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.
4. Air-Pressure Maintenance Device for Dry-Pipe Valve:
   a. Standard: UL 260.
   b. Description: Automatic device to maintain minimum air pressure in piping.
   c. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14 to 60 psig adjustable range, and 175 psig outlet pressure.
5. Air Compressor for Dry-Pipe Valve:
   a. Motor Horsepower: Fractional.
   b. Power: 120 V ac, 60 Hz, single phase.
   c. Sized for application and capable of achieving system supervisory pressure within 30 minutes in accordance with requirements of NFPA standards. Provide ASME air receiver tank as required to meet requirements on larger systems.
   d. Include filters, relief valves, coolers, automatic drains, and gauges.

H. System Control Valve, Pre-action Valve:

1. Standard: UL 260.
2. Design: Hydraulically operated, differential-pressure type.
3. Include trim sets for alarm-test bypass, drain, electrical water-flow alarm switch, pressure gauges, drip cup assembly piped without valves and separate from main drain line, and fill-line attachment with strainer.
4. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gauges; low-air-pressure warning switch; air-relief valve; and actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.

5. Air-Pressure Maintenance Device for Pre-action Valve:
   a. Standard: UL 260.
   b. Description: Automatic device to maintain minimum air pressure in piping.
   c. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14 to 60 psig adjustable range, and 175 psig outlet pressure.
6. Air Compressor for Pre-action Valve:
   a. Motor Horsepower: Fractional.
   b. Power: 120 V ac, 60 Hz, single phase.
   c. Sized for application and capable of achieving system supervisory pressure within 30 minutes in accordance with requirements of NFPA standards. Provide ASME air receiver tank as required to meet requirements on larger systems.
   d. Include filters, relief valves, coolers, automatic drains, and gauges.

2.7 DRY-SPRINKLER SYSTEM NITROGEN GENERATOR WITH PURGE/VENT - NOT USED

2.8 PREACTION SPRINKLER SYSTEM NITROGEN GENERATOR WITH PURGE/VENT – NOT USED

2.9 FIRE-SUPPRESSION PIPING SPECIALTIES

A. Branch Outlet Fittings:
   1. Standard: UL 213.
   2. Pressure Rating: 75 psig minimum.
   3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
   4. Type: Mechanical-tee and -cross fittings.
   5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
   6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
   7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Branch Line Testers:
   1. Standard: UL 199.
   2. Pressure Rating: 175 psig.
   3. Body Material: Brass.
   4. Size: Same as connected piping.
   5. Inlet: Threaded.
   6. Drain Outlet: Threaded and capped.
   7. Branch Outlet: Threaded, for sprinkler.

C. Sprinkler Inspector's Test Fittings:

1. Standard: ULSE's "Fire Protection Equipment Directory" or FM Approvals' "Approval Guide."
2. Pressure Rating: 175 psig.
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

D. Adjustable Drop Nipples:
1. Standard: UL 1474.
2. Pressure Rating: 250 psig minimum.
3. Body Material: Steel pipe with EPDM-rubber O-ring seals.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

E. Flexible Sprinkler Hose Fittings:
1. Not allowed.

F. Automatic Air Vent:
1. Description: Automatic air vent that automatically vents trapped air without human intervention. Approved for use in wet-pipe fire-suppression system.
2. Vents oxygen continuously from system.
3. Float valve to prevent water discharge.
4. Minimum Water Working Pressure Rating: 175 psig.

G. Automatic Air Vent Assembly:
1. Description: Automatic dual air vent assembly that automatically vents trapped air without human intervention, including Y-strainer and ball valve in a pre-piped assembly. Approved for use in wet-pipe fire-suppression system.
2. Vents oxygen continuously from system.
3. Float valve to prevent water discharge.
4. Minimum Water Working Pressure Rating: 175 psig.

2.10 COVER SYSTEMS FOR SPRINKLER PIPING – NOT USED

2.11 SPRINKLERS

A. Listed in ULSE's "Fire Protection Equipment Directory" or FM Approvals' "Approval Guide."

B. Pressure Rating for Sprinklers:
1. Standard Automatic Sprinklers: 175 psig minimum.

C. Sprinklers, Automatic Wet with Heat-Responsive Element:

1. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
2. Standard Spray, Standard Response:
    a. Upright.
    b. Pendent.
    c. Recessed pendent.
    d. Flat, concealed pendent.
    e. Vertical sidewall.
    f. Horizontal sidewall.

D. Sprinklers, Automatic Dry with Heat-Responsive Element:
1. Standard Spray, Standard Response:
    a. Upright.
    b. Pendent.
    c. Recessed pendent.
    d. Flat, concealed pendent.
    e. Horizontal sidewall.

E. Special Sprinklers:
1. Institutional.

F. Sprinkler Finishes: Chrome plated.

G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
1. Ceiling Mounting: Chrome-plated steel, one piece, flat, two piece, with 1-inch vertical adjustment.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

H. Sprinkler Guards and Water Shields:
1. Standard: UL 199.
2. Description: Wire cage with fastening device for attaching to sprinkler.

2.12 ALARM DEVICES

A. Match alarm-device material and connection types to piping and equipment materials and connection types.

B. Water-Motor-Operated Alarm:
1. Standard: UL 753.
2. Type: Mechanically operated, with Pelton wheel.

3. Alarm Gong: Cast aluminum with red-enamel factory finish.
4. Size: [8-1/2-inch (216-mm)] [10-inch (250-mm)] [Insert diameter] diameter.
5. Components: Shaft length, bearings, and sleeve to suit wall construction.
6. Inlet: NPS 3/4 (DN 20).
7. Outlet: NPS 1 (DN 25) drain connection.

C. Electrically Operated Notification Appliances:
1. Sign, Integrated:

D. Water-Flow Indicators:
1. Standard: UL 346.
2. Water-Flow Detector: Electrically supervised.
3. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125 V ac and 0.25 A, 24 V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
4. Type: Paddle operated.
5. Pressure Rating: 250 psig (1725 kPa).
6. Design Installation: Horizontal or vertical.

E. Pressure Switches - Water-Flow Alarm Detection:
1. Description: Electrically supervised, pressure-activated water-flow switch with retard feature.
2. Components: Two single-pole, double-throw switches with normally closed contacts.
3. Design Operation: Rising pressure to 6 psi (40 kPa), plus or minus 2 psi signals water flow.
4. Adjustability: Each switch is to be independently adjustable.
5. Wire Separation: Pressure switch to provide for separation of wiring to each switch connection to allow for low- and high-voltage connections to comply with NFPA 70, Article 760 requirements.

F. Pressure Switches - Low/High Air Pressure Supervisory:
1. Description: Electrically supervised pressure supervisory switch.
2. Components: Two single-pole, double-throw switches.
3. Design Operation: Detects increase and/or decrease from normal supervisory air pressure.
4. Adjustability: Each switch is to be independently adjustable.
5. Wire Separation: Pressure switch to provide for separation of wiring to each switch connection to allow for low- and high-voltage connections to comply with NFPA 70, Article 760 requirements.

G. Valve Supervisory Switches:
1. Standard: UL 346.
2. Type: Electrically supervised.

3. Design: Signals that controlled valve is in other than fully open position.
4. Wire Terminal Designations: Indicates normal switch position when switch is properly installed on valve and valve is fully open.
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. OS&Y Valve Supervisory Switches:
    a. One or two single-pole, double-throw switches.
    b. NEMA Rating: NEMA 4 and NEMA 6P enclosures suitable for mounting in any position indoors or outdoors.
    c. Visual Switch Indication: Indicates device is properly installed and OS&Y valve is fully open.
    d. Mounting Hardware: Mounting bracket to grip valve yoke and prevent movement of switch assembly on OS&Y valve.
    e. Trip Rod Length: Adjustable

2.13 MANUAL CONTROL STATIONS - NOT USED

2.14 CONTROL PANELS – NOT USED

A. PRESSURE GAUGES Standard: UL 393.

B. Dial Size: 3-1/2- to 4-1/2-inch diameter.

C. Pressure Gauge Range: 0 to 250 psig (0 to 1725 kPa) minimum.

D. Water System Piping Gauge: Include "WATER" or "AIR/WATER" label on dial face.

E. Air System Piping Gauge: Include retard feature and "AIR" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test. Use results for system design calculations required in "Quality Assurance" Article.

1. Flow test is to be performed to meet the criteria established by NFPA 13.
2. Flow test is to be conducted in accordance with NFPA 291.
3. Test is to be performed during a period of ordinary demand for the water system.
    a. To obtain satisfactory test results of expected flow or rated capacities, sufficient discharge should be achieved to cause drop of at least 10 percent.
4. Pitot readings are to be taken at the 2-1/2-inch (65-mm) orifice connection.
5. The pitot reading is to range from 10 to 35 psig (68.9 kPa to 241.3 kPa).
6. Open additional hydrant outlets as needed to control pitot readings.
7. The pitot pressure and corresponding residual pressure readings are to be taken consecutively as pressure fluctuates between a high number and low number.

B. Flow Test Data Written Report:
   1. Flow data report is to be written in accordance with NFPA 291.
   2. Flow data report is to include a copy of all flow data recorded during the test, including a site plan showing the tested fire hydrants with respect to the fire water service to the building. Site plan is to indicate which hydrant was flowed and which hydrant was used for pressure reading. Provide date of test, name of testing agency, and name of individual performing test.

C. Water Supply Curve: Provide water supply curve based on the lowest supply for a given set of test data. For a given residual pressure reading, the supply is to be graphed utilizing the corresponding pitot pressure/flow reading and static pressure reading.

D. Documentation is to include calibration certifications for gauges used in the flow tests. The certifications are to be from within the previous six (6) months from a reputable agency recognized for certifying pressure gauges.

E. Report flow test results promptly and in writing. A copy of the flow test data report is to be submitted with the hydraulic calculations.

3.2 INSTALLATION OF FIRE-SUPPRESSION WATER-SERVICE PIPING

A. Comply with requirements for fire-suppression water-service piping in Section 331415 "Site Water Distribution Piping."

3.3 INSTALLATION OF DOMESTIC WATER-SUPPLY CONNECTIONS

A. Connect fire-suppression water piping to building's interior domestic water-distribution piping. Comply with requirements for interior piping in Section 221116 "Domestic Water Piping."

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements for backflow preventers in Section 331415 "Site Water Distribution Piping."

3.4 INSTALLATION OF FIRE-SUPPRESSION PIPING

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
   1. Deviations from approved working plans for piping require written approval from AHJs. File written approval with Architect before deviating from approved working plans.
   2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of fire-suppression piping.

C. Install seismic restraints on piping. Comply with NFPA standards requirements for seismic-restraint device materials and installation.

D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

G. Install inspector's test connections in sprinkler system piping, complete with shutoff valve, and sized and located in accordance with NFPA 13.

H. Install fire-suppression system piping with drains for complete system drainage. Extend drain piping to exterior of building where possible.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valve at each check valve for fire department connection, to drain piping between fire department connection and check valve. Install drain piping to and spill over floor drain or to exterior of building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for fire-suppression piping in accordance with NFPA standards. Comply with requirements for hanger materials in NFPA standards. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe/sprinkler supply. Include pressure gauges with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they are not subject to freezing.

N. Pressurize and check dry-pipe pre-action standpipe or sprinkler system piping and air compressors.

O. Fill wet-type fire-suppression system piping with water.

P. Drain dry-type fire-suppression system piping.

1. Install electric heating cables and pipe insulation on fire-suppression piping in areas subject to freezing. Comply with requirements for heating cables in Section 210533 "Heat Tracing for Fire-Suppression Piping" and for piping insulation in Section 210700 "Fire-Suppression Systems Insulation."

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210500 "Common Work Results for Fire-Suppression Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210500 "Common Work Results for Fire-Suppression Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210500 "Common Work Results for Fire-Suppression Piping."

3.5 INSTALLATION OF PIPING JOINTS

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts in accordance with ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Pressure-Sealed Joints: Join steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

J. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

K. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe in accordance with AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings in accordance with AWWA C606 for steel-pipe joints.

L. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe in accordance with AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings in accordance with AWWA C606 for steel-pipe grooved joints.

M. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

N. Plastic-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join in accordance with ASTM D2846/D2846M Appendix.

3.6 INSTALLATION OF FIRE DEPARTMENT CONNECTIONS

A. Install wall-type fire department connections.

B. Install two protective pipe bollards [around] [on sides of] each fire department connection.

C. Install automatic (ball-drip) drain valve at each check valve for fire department connection.

3.7 INSTALLATION OF HOSE CONNECTIONS AND HOSE STATIONS – NOT USED

3.8 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING – NOT USED

3.9 INSTALLATION OF VALVES AND SPECIALTIES

A. Install listed fire-suppression system control valves, trim and drain valves, specialty valves and trim, controls, and specialties in accordance with manufacturer's installation instructions, NFPA standards, and AHJ.

B. Install listed fire-suppression system shutoff valves in supervised open position, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. System Control Valves:

1. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
2. Install dry-pipe valves with trim sets for air supply, drain, priming level, alarm connections, ball-drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.
    a. Install air compressor and compressed-air-supply piping.
    b. Install air-pressure maintenance device with shutoff valves to permit servicing without shutting down system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14 to 60 psig adjustable range; and 175 psig maximum inlet pressure.
    c. Install compressed-air-supply piping from building's compressed-air piping system.
3. Install deluge valves with trim sets for drain, priming level, alarm connections, ball-drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.

D. Air Vent:

1. Provide at least one air vent at high point in each wet-pipe fire-suppression system in accordance with NFPA standards. Connect vent into top of fire-suppression piping.

2. Provide dielectric union for dissimilar metals, ball valve, and strainer upstream of automatic air vent.
3. Pipe from outlet of air vent to drain.

3.10 INSTALLATION OF SPRINKLERS

A. Install sprinklers in suspended ceilings symmetrically in center of narrow dimension of acoustical ceiling panels within tolerance of 1/2 inch. Coordinate entire pattern of sprinkler locations with approved reflected ceiling plan.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

3.11 INSTALLATION OF NITROGEN GENERATOR WITH PURGE/VENT SYSTEM – NOT USED

3.12 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping in accordance with requirements for identification specified in Section 210553 "Identification for Fire-Suppression Piping and Equipment."

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.13 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect fire-suppression systems in accordance with NFPA standards.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire department equipment.
9. Verify that sprinklers' original factory finish has not been contaminated with dirt, debris, or paint. Sprinklers containing other-than-original factory finish are to be considered defective and replaced with new products. Repair and/or cleaning is not acceptable.

C. Fire-suppression piping system will be considered defective if it does not pass tests and inspections.

D. Fire-suppression piping system components considered defective during testing will be replaced with new components. Repair of defective components is not acceptable.

E. Prepare test and inspection reports.

3.14 CLEANING

A. Clean dirt and debris from fire-suppression system piping, system control valves, sprinklers, and associated components.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.15 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain system control valves.

3.16 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2 (DN 50) and Smaller, to Be One of the Following:

1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Schedule 40, black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
4. Schedule 40, galvanized-steel pipe with plain ends; galvanized, plain-end-pipe fittings; and twist-locked joints.
5. Schedule 40, black-steel pipe with cut or roll grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
6. Schedule 40, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
7. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
8. Schedule 10 engineered light-wall, steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
9. Schedule 10 engineered light-wall, steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
10. Schedule 10 engineered light-wall, steel pipe with plain ends; welding fittings; and welded joints.

C. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), to Be One of the Following:
   1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   2. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   3. Schedule 40, black-steel pipe with cut or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   4. Schedule 40, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   5. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   6. Schedule 10 engineered light-wall, steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   7. Schedule 10 engineered light-wall, steel pipe with plain ends; welding fittings; and welded joints.

D. Standard-Pressure, Wet-Pipe Sprinkler System, NPS 5 (DN 125) and Larger, to Be One of the Following:
   1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   2. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   3. Schedule 40, black-steel pipe with cut or roll grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   4. Schedule 40, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   5. Schedule 40, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   6. Schedule 10 or engineered light-wall, steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   7. Schedule 10 engineered light-wall, steel pipe with plain ends; welding fittings; and welded joints.

3.17 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:
   1. Rooms without Ceilings: Upright sprinklers
   2. Rooms with Suspended Ceilings: Recessed sprinklers, recessed, flat concealed, vertical sidewall sprinklers as indicated.

3. Wall Mounting: Horizontal sidewall sprinklers.
4. Spaces Subject to Freezing: Dry pendent sprinklers.
5. Special Applications: Institutional space sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces and locations not generally exposed to view; and wax coated where exposed to acids, chemicals, or other corrosive fumes.
2. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
3. Flat Concealed Sprinklers: Rough brass, with factory-painted white cover plate.

END OF SECTION 211000

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SECTION 220517

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Silicone sealants.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.

E. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

A. Description: Manufactured, Dura-coated or Duco-coated cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20 psig minimum.
3. Sealing Elements: EPDM-rubber High-temperature-silicone Nitrile (Buna N)interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Composite plastic.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 or Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

B. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C 920, Type S, Grade NS, Class 25, Use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

C. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
   1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
   1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
   2. Cut sleeves to length for mounting flush with both surfaces.
      a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
   3. Using grout or silicone sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.
   1. Cut sleeves to length for mounting flush with both surfaces.
   2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.
   1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
   2. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
   3. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   4. Use silicone sealant to seal the space around outside of stack-sleeve fittings.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Use grout or silicone sealant to seal the space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6: Steel pipe sleeves PVC pipe sleeves Stack-sleeve fittings Sleeve-seal fittings Molded-PE or -PP sleeves Molded-PVC sleeves or Galvanized-steel sheet sleeves.

b. Piping NPS 6 and Larger: Steel pipe sleeves PVC pipe sleeves Stack-sleeve fittings or Galvanized-steel sheet sleeves.

2. Interior Partitions:

a. Piping Smaller Than NPS 6: Steel pipe sleeves or Galvanized-steel sheet sleeves.

b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 220517

SECTION 220523.12

BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, and soldered ends.
3. Set ball valves open to minimize exposure of functional surfaces.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B16.18 for solder-joint connections.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Handlever: For quarter-turn valves smaller than NPS 4.

H. Valves in Insulated Piping:

1. Include 2-inch stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRASS BALL VALVES

A. Brass Ball Valves, Two-Piece with Full Port and Brass Trim, Threaded or Soldered Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Apollo Flow Controls; Conbraco Industries, Inc.
   b. NIBCO INC.
   c. WATTS.
2. Description:
   a. Standard: MSS SP-110 or MSS SP-145.
   b. CWP Rating: 600 psig.
   c. Body Design: Two piece.
   d. Body Material: Forged brass.
   e. Ends: Threaded and soldered.
   f. Seats: PTFE.
   g. Stem: Brass.
   h. Ball: Chrome-plated brass.
   i. Port: Full.

B. Brass Ball Valves, Two-Piece with Full Port and Brass Trim, Press Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Apollo Flow Controls; Conbraco Industries, Inc.

b. NIBCO INC.
c. WATTS.

2. Description:
a. Standard: MSS SP-110 or MSS SP-145.
b. CWP Rating: Minimum 200 psig.
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Press.
f. Press Ends Connections Rating: Minimum 200 psig.
g. Seats: PTFE or RPTFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.
k. O-Ring Seal: Buna-N or EPDM.

C. Brass Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim, Threaded or Soldered Ends:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Apollo Flow Controls; Conbraco Industries, Inc.
b. NIBCO INC.
2. Description:
a. Standard: MSS SP-110 or MSS SP-145.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Full.

D. Brass Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim, Press Ends:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. NIBCO INC.

2. Description:
a. Standard: MSS SP-110 or MSS SP-145.
b. CWP Rating: Minimum 200 psig.
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Press.
f. Press Ends Connections Rating: Minimum 200 psig.
g. Seats: PTFE or RPTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.
k. O-Ring Seal: Buna-N or EPDM.

E. Brass Ball Valves, Three-Piece with Full Port and Brass Trim:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. WATTS.
2. Description:
a. Standard: MSS SP-110.
b. CWP Rating: 600 psig.
c. Body Design: Three piece.
d. Body Material: Forged brass.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

2.3 BRONZE BALL VALVES

A. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Apollo Flow Controls; Conbraco Industries, Inc.
b. NIBCO INC.
c. WATTS.

2. Description:
a. Standard: MSS SP-110 or MSS-145.
b. CWP Rating: 600 psig.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Bronze or brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

B. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Press Ends:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Apollo Flow Controls; Conbraco Industries, Inc.
b. NIBCO INC.
c. WATTS.

2. Description:
a. Standard: MSS SP-110 or MSS-145.
b. CWP Rating: Minimum 200 psig.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Press.
f. Press Ends Connections Rating: Minimum 200 psig.
g. Seats: PTFE or RTPFE.
h. Stem: Bronze or brass.
i. Ball: Chrome-plated brass.
j. Port: Full.
k. O-Ring Seal: EPDM or Buna-N.

C. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. Apollo Flow Controls; Conbraco Industries, Inc.
    b. NIBCO INC.
    c. WATTS.
2. Description:
    a. Standard: MSS SP-110 or MSS-145.
    b. CWP Rating: 600 psig.
    c. Body Design: Two piece.
    d. Body Material: Bronze.
    e. Ends: Threaded or soldered.
    f. Seats: PTFE.
    g. Stem: Stainless steel.
    h. Ball: Stainless steel, vented.
    i. Port: Full.

D. Bronze Ball Valves, Three-Piece with Full Port and Bronze or Brass Trim:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. Apollo Flow Controls; Conbraco Industries, Inc.
    b. NIBCO INC.
    c. WATTS.
2. Description:
    a. Standard: MSS SP-110.
    b. CWP Rating: 600 psig.
    c. Body Design: Three piece.
    d. Body Material: Bronze.
    e. Ends: Threaded.
    f. Seats: PTFE.
    g. Stem: Bronze or brass.
    h. Ball: Chrome-plated brass.
    i. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Brass ball valves, two-piece with full port and brass or stainless steel trim. Provide with solder or press connection-joint ends.
2. Bronze ball valves, two-piece with full port and bronze or brass or stainless steel trim. Provide with solder or press connection-joint ends.
3. Brass ball valves, three-piece with full port and brass or stainless steel trim.
4. Bronze ball valves, three-piece with full port and bronze or brass or stainless steel trim.

END OF SECTION 220523.12

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SECTION 220529

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal hanger-shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Pipe-positioning systems.
8. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.3 ACTION SUBMITTALS

A. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

B. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly, made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4, factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel or extruded-aluminum channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Paint Coating: Green epoxy, acrylic, or urethane.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly, made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
2. Standard: Comply with MFMA-4, factory-fabricated components for field assembly.
3. Channels: Continuous slotted carbon-steel or stainless-steel channel with inturned lips.
4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Paint Coating: Green epoxy, acrylic, or urethane.

2.5 THERMAL HANGER-SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or stainless steel.
2. Outdoor Applications: Stainless steel.

2.7 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand:

1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Hardware: Galvanized steel or polycarbonate.
4. Accessories: Protection pads.

C. Low-Profile, Single-Base, Single-Pipe Stand:

1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
3. Vertical Members: Two galvanized or stainless-steel, continuous-thread, 1/2-inch rods.
4. Horizontal Member: Adjustable horizontal, galvanized or stainless-steel pipe support channels.
5. Pipe Supports: Strut clamps.
6. Hardware: Galvanized or Stainless steel.
7. Accessories: Protection pads.
8. Height: 6 inches above roof.

D. High-Profile, Single-Base, Single-Pipe Stand:

1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

2. Base: Single vulcanized rubber or molded polypropylene.
3. Vertical Members: Two galvanized or stainless-steel, continuous-thread, 1/2-inch rods.
4. Horizontal Member: One adjustable-height, galvanized- or stainless-steel, pipe-support slotted channel or plate.
5. Pipe Supports: Roller.
6. Hardware: Galvanized or Stainless steel.
7. Accessories: Protection pads, 1/2-inch, continuous-thread, galvanized-steel rod or, 1/2-inch, continuous-thread, stainless-steel rod.
8. Height: 24 inches above roof.

E. High-Profile, Multiple-Pipe Stand:
1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; molded polypropylene.
3. Vertical Members: Two or more, galvanized or stainless-steel channels.
4. Horizontal Members: One or more, adjustable-height, galvanized or stainless-steel pipe support.
5. Pipe Supports: Strut clamps.
6. Hardware: Galvanized or Stainless steel.
7. Accessories: Protection pads, 1/2-inch, continuous-thread rod.
8. Height: 24 inches above roof.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.8 PIPE-POSITIONING SYSTEMS

A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.9 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

2.10 MATERIALS

A. Aluminum: ASTM B 221.
B. Carbon Steel: ASTM A 1011/A 1011M.
C. Structural Steel: ASTM A 36/A 36M carbon-steel plates, shapes, and bars; black and galvanized.
D. Stainless Steel: ASTM A 240/A 240M.

E. Grout: ASTM C 1107/C 1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   1. Properties: Nonstaining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.

E. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

F. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Pipe Stand Installation:
   1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.

2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

H. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

P. Insulated Piping:

1. Attach clamps and spacers to piping.
   a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
   e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099123 "Interior Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal hanger-shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
   1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
   2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
   3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
   4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction occurs.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

S. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

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SECTION 220548.13

VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Pipe-riser resilient supports.
7. Resilient pipe guides.
8. Elastomeric hangers.
9. Spring hangers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device type required.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Smooth pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.
7. Sandwich-Core Material: elastomeric.
   a. Surface Pattern: Smooth pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Mounting Plates:
   a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
   b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   a. Housing: Cast-ductile iron or welded steel.
   b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig.
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig.
    b. Top housing with elastomeric pad.

2.6 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.7 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.8 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.9 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete." vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

END OF SECTION 220548.13

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SECTION 220553

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch stainless steel, 0.025-inch aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater

viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black.
3. Background Color: White.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions and as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 STENCILS

A. Stencils for Piping:

1. Lettering Size: Size letters according to ASME A13.1 for piping.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch stainless steel, 0.025-inch aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass wire-link chain or beaded chain or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or

space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
   a. Cold Water: 1-1/2 inches, round.
   b. Hot Water: 1-1/2 inches, round.
2. Valve-Tag Colors:
   a. Cold Water: Natural.
   b. Hot Water: Natural.
3. Letter Colors:
   a. Cold Water: Black.
   b. Hot Water: Black.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 220553

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SECTION 220719

PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Roof drains and rainwater leaders.
5. Supplies and drains for handicap-accessible lavatories and sinks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

G. Mineral-Fiber, Preformed Pipe Insulation:

1. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
2. Service Temperature Range: 0 to 180 deg F.
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
2. Service Temperature Range: Minus 50 to plus 220 deg F.
3. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
3. Service Temperature Range: 0 to plus 180 deg F.
4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 100 ounces force/inch in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch in width.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
    a. For below-ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.

5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. For joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket application.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.

2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:
   1. NPS 1 and Smaller: Insulation shall be one of the following:
      a. Flexible Elastomeric: 1/2 inch thick.
   2. NPS 1-1/4 and Larger: Insulation shall be one of the following:
      a. Flexible Elastomeric: 1/2 inch thick.

B. Domestic Hot and Recirculated Hot Water:
   1. NPS 1 and Smaller: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
   2. NPS 1-1/4 and Larger: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Horizontal Stormwater and Overflow:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Roof Drain and Overflow Drain Bodies:
   1. All Pipe Sizes: Insulation shall be one of the following:
      a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

E. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Prefabicated ADA insulation kits with PVC covers for drains and domestic water piping.

F. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
   1. All Pipe Sizes: Insulation shall be the following:
      a. Flexible Elastomeric: 3/4 inch thick.

END OF SECTION 220719

SECTION 221116

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Ductile-iron pipe and fittings.
3. Piping joining materials.
4. Transition fittings.
5. Dielectric fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

A. System purging and disinfecting activities report.

B. Field quality-control reports.

1.5 FIELD CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not interrupt water service without Construction Manager's and Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

G. Fitting Connection Type: Sweat Solder-Joint. Press connection type fittings are not allowed.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.

2.4 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys.

D. Flux: ASTM B 813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.5 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Standard: ASSE 1079.
2. Pressure Rating: 150 psig.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Standard: ASSE 1079.
2. Factory-fabricated, bolted, companion-flange assembly.
3. Pressure Rating: 150 psig.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Nonconducting materials for field assembly of companion flanges.
2. Pressure Rating: 150 psig.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Standard: IAPMO PS 66.
2. Electroplated steel nipple complying with ASTM F 1545.
3. Pressure Rating and Temperature: 300 psig at 225 deg F.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate

friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

G. Install domestic water piping level without pitch and plumb.

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

K. Install piping to permit valve servicing.

L. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

C. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

D. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."

E. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

F. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.3 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 and Larger: Sleeve-type coupling.

3.4 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
    a. MSS Type 1, adjustable, steel clevis hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
4. NPS 2-1/2: 108 inches with 1/2-inch rod.
5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
6. NPS 6: 10 feet with 5/8-inch rod.
7. NPS 8: 10 feet with 3/4-inch rod.

E. Install supports for vertical copper tubing every 10 feet.

F. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.7 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.

b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.

2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.

d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.

f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:
      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Repeat procedures if biological examination shows contamination.
   e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.11 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, NPS 2 1/2 and smaller, shall be the following:
   1. Copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

E. Under-building-slab, domestic water, building-service piping, NPS 3 and larger, shall be the following:
   1. Mechanical-joint, ductile-iron pipe; standard- or compact-pattern, mechanical-joint fittings; and mechanical joints.

F. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:
   1. Hard or soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.

G. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
   2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

H. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and brazed joints.

2. Hard copper tube, ASTM B 88, Type L copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B 88, Type L grooved-joint, copper-tube appurtenances; and grooved joints.

3.12 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
3. Hot-Water Circulation Piping, Balancing Duty: Calibrated or Memory-stop balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221116

SECTION 221119

DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Balancing valves.
4. Strainers.
5. Outlet boxes.
6. Hose stations.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water-hammer arresters.
11. Air vents.
12. Trap-seal primer valves.
13. Trap-seal primer systems.
14. Flexible connectors.

B. Related Requirements:

1. Section 221116 "Domestic Water Piping" for water meters.
2. Section 224500 "Emergency Plumbing Fixtures" for water tempering equipment.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

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

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61.

B. Comply with NSF 372 for low lead.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Apollo Flow Controls; Conbraco Industries, Inc.
   b. WATTS.
   c. Woodford Manufacturing Company.
   d. Zurn Industries, LLC.
2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

2.4 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Apollo Flow Controls; Conbraco Industries, Inc.
   b. WATTS.
   c. Zurn Industries, LLC.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Design Outlet Pressure Setting: 75 psig.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
6. Valves for Booster Heater Water Supply: Include integral bypass.
7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.5 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. NIBCO INC.
      b. WATTS.
   2. Type: Ball valve with two readout ports and memory-setting indicator.
   3. Body: Brass or bronze.
   4. Size: Same as connected piping, but not larger than NPS 2.
   5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

C. Memory-Stop Balancing Valves:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Apollo Flow Controls; Conbraco Industries, Inc.
      b. NIBCO INC.
   2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
   3. Pressure Rating: 400-psig minimum CWP.
   4. Size: NPS 2 or smaller.
   5. Body: Copper alloy.
   6. Port: Standard or full port.
   7. Ball: Chrome-plated brass.
   8. Seats and Seals: Replaceable.
   9. End Connections: Solder joint or threaded.
   10. Handle: Vinyl-covered steel with memory-setting device.

D. Individual-Fixture, Water Tempering Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Apollo Flow Controls; Conbraco Industries, Inc.
      b. WATTS.
      c. Zurn Industries, LLC.
   2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
   3. Pressure Rating: 125 psig minimum unless otherwise indicated.

4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.
8. Tempered-Water Setting: 110 deg F.
9. Tempered-Water Design Flow Rate: 2.5 gpm.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:
1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
a. Strainers NPS 2 and Smaller:0.033 inch.
b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
c. Strainers NPS 5 and Larger: 0.10 inch.
6. Drain: Factory-installed, hose-end drain valve.

2.7 OUTLET BOXES

A. Icemaker Outlet Boxes:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. IPS Corporation.
b. Oatey.
c. Plastic Oddities.
d. Sioux Chief Manufacturing Company, Inc.
2. Mounting: Recessed.
3. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.8 HOSE BIBBS

A. Hose Bibbs:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. WATTS.
   b. Woodford Manufacturing Company.
   c. Zurn Industries, LLC.
2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig.
8. Vacuum Breaker: Integral or field-installation, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Finish for Service Areas:Chrome or nickel plated.
11. Finish for Finished Rooms: Chrome or nickel plated.
12. Operation for Equipment Rooms: Wheel handle or operating key.
13. Operation for Service Areas: Operating key.
14. Operation for Finished Rooms: Operating key.
15. Include operating key with each operating-key hose bibb.
16. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. WATTS.
      b. Woodford Manufacturing Company.
      c. Zurn Industries, LLC.
   2. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
   3. Pressure Rating: 125 psig.
   4. Operation: Loose key.

5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
12. Operating Keys(s): One Two with each wall hydrant.

B. Nonfreeze Roof Hydrants:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. WATTS.
   b. Woodford Manufacturing Company.
   c. Zurn Industries, LLC.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Latch.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet:
   a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
   b. Garden-hose thread complying with ASME B1.20.7.
7. Mounting: Roof mounted.
8. Outlet:
   a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
   b. Garden-hose thread complying with ASME B1.20.7.
9. Finish: Powder Coated.

2.10 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.11 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Precision Plumbing Products.
   b. Sioux Chief Manufacturing Company, Inc.
   c. WATTS.
   d. Zurn Industries, LLC.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type:Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.12 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Precision Plumbing Products.
   b. Sioux Chief Manufacturing Company, Inc.
   c. WATTS.
   d. Zurn Industries, LLC.
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.

4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.13 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. Precision Plumbing Products.
b. Sioux Chief Manufacturing Company, Inc.
c. Zurn Industries, LLC.
2. Standard: ASSE 1044.
3. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
4. Cabinet: Surface-mounted steel box with stainless-steel cover.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: As needed.
8. Size Outlets: NPS 1/2.

2.14 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Flexicraft Industries.
2. Sioux Chief Manufacturing Company, Inc.
3. Universal Metal Hose.

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: Minimum 200 psig.
2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Backflow Preventers: Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
   1. Locate backflow preventers in same room as connected equipment or system.
   2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
   3. Do not install bypass piping around backflow preventers.

B. Water Regulators: Install with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

C. Automatic Water Shutoff Valves: Test for signal strength before valve installation. Install automatic shutoff valve downstream from main domestic water shutoff valve and downstream from fire sprinkler system supply. Install valve controller is an accessible location with sensors in areas where water is likely to accumulate.

D. Balancing Valves: Install in locations where they can easily be adjusted.

E. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.
   1. Install cabinet-type units recessed in or surface mounted on wall as specified.

F. Y-Pattern Strainers: For water, install on supply side of each water pressure-reducing valve or solenoid valve.

G. Outlet Boxes: Install boxes recessed in wall or surface mounted on wall.

H. Water-Hammer Arresters: Install in water piping according to PDI-WH 201.

I. Supply-Type, Trap-Seal Primer Device: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

J. Trap-Seal Primer Systems: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

C. Comply with requirements for grounding equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Reduced-pressure-principle backflow preventers.
2. Double-check, backflow-prevention assemblies.
3. Water pressure-reducing valves.
4. Automatic water shutoff valves.
5. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each pressure vacuum breaker reduced-pressure-principle backflow preventer double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 221123.21

INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. In-line, seal less centrifugal pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction materials, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail pumps and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which pumps will be attached.
2. Size and location of initial access modules for acoustical tile.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For inline, domestic-water pumps to include in operation and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. UL Compliance: UL 778 for motor-operated water pumps.

C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

2.2 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Grundfos Pumps Corp.

C. Characteristics:

1. Pump Control: Thermostat and Timer.

D. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Minimum Working Pressure: 125 psig.
3. Maximum Continuous Operating Temperature: 200 deg F.
4. Casing: Cast iron Bronze or Stainless steel, with threaded or companion-flange connections.
5. Impeller: stainless steel.
6. Motor: Three speed.

2.3 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Clip on piping.
2. Operation of Pump: On or off.
3. Transformer: Provide if required.
4. Power Requirement:120 V ac.
5. Settings: Start pump at 135 deg F and stop pump at 145 deg F.

B. Timers: Electric, for control of hot-water circulation pump.

1. Type: Programmable, seven-day clock with manual override on-off switch.
2. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Power Requirement: 120 V ac.
6. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for domestic-water-piping system to verify actual locations of piping connections before pump installation.

3.2 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Mount pumps in orientation complying with manufacturer's written instructions.

C. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.

1. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required.

2. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

D. Connect thermostat to hot-water return piping.

E. Install timer on wall in near pump.

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.

C. Connect domestic-water piping to pumps.

D. Install shutoff valve and strainer on suction side of each pump, and install check, and shutoff on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in the following:

1. Section 220523.12 "Ball Valves for Plumbing Piping."

2. Section 220523.14 "Check Valves for Plumbing Piping."

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between temperature controllers and devices.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats, and timers for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:
   a. Verify bearing lubrication.
   b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
   c. Verify that pump is rotating in the correct direction.
6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.8 ADJUSTING

A. Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123.21

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SECTION 221316

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Hubless, cast-iron soil pipe and fittings.
2. PVC pipe and fittings.
3. Specialty pipe fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

C. All above ground piping shall be cast iron and all underground piping shall be PVC.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Single-Stack Aerator Fittings: ASME B16.45, hubless, cast-iron aerator and deaerator drainage fittings.

C. CISPI, Hubless-Piping Couplings:

1. Charlotte Pipe and Foundry Company.
2. Fernco Inc.
3. Mission Rubber Company, LLC; a division of MCP Industries.

D. Cast-Iron, Hubless-Piping Couplings:

1. Charlotte Pipe and Foundry Company.
2. Standard: ASTM C 1277.
3. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 DUCTILE-IRON PIPE AND FITTINGS

A. Ductile-Iron, Mechanical-Joint Piping:

1. Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot ends unless grooved or flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, mechanical-joint, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.

B. Ductile-Iron, Push-on-Joint Piping:

1. Ductile-Iron Pipe: AWWA C151/A21.51, with push-on-joint bell and plain spigot ends unless grooved or flanged ends are indicated.
2. Ductile-Iron Fittings: AWWA C110/A21.10, push-on-joint, ductile- or gray-iron standard pattern or AWWA C153/A21.53, ductile-iron compact pattern.
3. Gaskets: AWWA C111/A21.11, rubber.

C. Ductile-Iron, Grooved-Joint Piping: AWWA C151/A21.51, with round-cut-grooved ends according to AWWA C606.

D. Ductile-Iron, Grooved-End Pipe Appurtenances:

1. Grooved-End, Ductile-Iron Fittings: ASTM A 536 ductile-iron castings, with dimensions matching AWWA C110/A 21.10 ductile-iron pipe or AWWA C153/A 21.53 ductile-iron fittings, and complying with AWWA C606 for grooved ends.
2. Grooved Mechanical Couplings for Ductile-Iron Pipe: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber center-leg gasket suitable for hot and cold water; and bolts and nuts.

2.5 PVC PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

C. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.

D. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

E. Adhesive Primer: ASTM F 656.

F. Solvent Cement: ASTM D 2564.

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2. Unshielded, Nonpressure Transition Couplings:

a. Standard: ASTM C 1173.

b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

c. End Connections: Same size as and compatible with pipes to be joined.

d. Sleeve Materials:

1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.

2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.

3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

3. Shielded, Nonpressure Transition Couplings:

a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1) Mission Rubber Company, LLC; a division of MCP Industries.

b. Standard: ASTM C 1460.

c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

d. End Connections: Same size as and compatible with pipes to be joined.

B. Dielectric Fittings:

1. Dielectric Unions:
   a. Description:
      1) Standard: ASSE 1079.
      2) Pressure Rating: 125 psig minimum at 180 deg F.
      3) End Connections: Solder-joint copper alloy and threaded ferrous.
2. Dielectric Flanges:
   a. Description:
      1) Standard: ASSE 1079.
      2) Factory-fabricated, bolted, companion-flange assembly.
      3) Pressure Rating: 125 psig minimum at 180 deg F.
      4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
3. Dielectric Nipples:
   a. Description:
      1) Standard: IAPMO PS 66.
      2) Electroplated steel nipple.
      3) Pressure Rating: 300 psig at 225 deg F.
      4) End Connections: Male threaded or grooved.
      5) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTH MOVING – NOT USED

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
   1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
   2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
   a. Straight tees, elbows, and crosses may be used on vent lines.
3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
   a. Reducing size of waste piping in direction of flow is prohibited.

L. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

O. Install underground PVC piping according to ASTM D 2321.

P. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
    a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
    b. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
2. Install drains in sanitary waste gravity-flow piping.
    a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

R. Install sleeves for piping penetrations of walls, ceilings, and floors.
1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs.
1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors.
1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 appendixes.
3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:
1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:
    a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
    b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:
   1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
   2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
   3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
   4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

A. Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping" for general-duty valve installation requirements.

B. Backwater Valves: Install backwater valves in piping subject to backflow.
   1. Horizontal Piping: Horizontal backwater valves.
   2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
   3. Install backwater valves in accessible locations.
   4. Comply with requirements for backwater valve specified in Section 221319 "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
   1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
   2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
   3. Vertical Piping: MSS Type 8 or Type 42, clamps.
   4. Install individual, straight, horizontal piping runs:
      a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
      b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
      c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
   5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

F. Install supports for vertical cast-iron soil piping every 15 feet.

G. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Equipment: Connect waste piping as indicated.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
   a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
   a. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
   a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
   b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
   c. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
   a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
   b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
   c. Air pressure must remain constant without introducing additional air throughout period of inspection.
   d. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 (DN 100) and smaller shall be the following:

1. Hubless, cast-iron soil pipe and fittings [and hubless, single-stack aerator fittings]; [CISPI] [heavy-duty] hubless-piping couplings; and coupled joints.

C. Aboveground, vent piping [NPS 4NPS 4 (DN 100) and smaller] <Insert pipe size range> shall be [any of] the following:

1. Hubless, cast-iron soil pipe and fittings; [CISPI] [heavy-duty] hubless-piping couplings; and coupled joints.

D. Underground, soil, waste, and vent piping NPS 4 and smaller shall be the following:

1. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

E. Underground, soil and waste piping NPS 5 and larger shall be the following:

1. Solid-wall PVC pipe; PVC socket fittings; and solvent-cemented joints.

END OF SECTION 221316

SECTION 221319

SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cleanouts.
2. Roof flashing assemblies.
3. Through-penetration firestop assemblies.
4. Miscellaneous sanitary drainage piping specialties.

B. Related Requirements:

1. Section 221423 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. FOG: Fats, oils, and greases.

C. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Shop Drawings:

1. Show fabrication and installation details for frost-resistant vent terminals.
2. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

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

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:
   1. Standard: ASME A112.36.2M.
   2. Size: Same as connected drainage piping
   3. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
   4. Closure: Countersunk, brass plug.
   5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:
   1. Standard: ASME A112.36.2M for adjustable housing cleanout.
   2. Size: Same as connected branch.
   3. Type: Adjustable housing
   4. Body or Ferrule: Cast iron.
   5. Clamping Device: Not required.
   6. Outlet Connection: Spigot.
   7. Closure: Brass plug with straight threads and gasket or Plastic plug.
   8. Adjustable Housing Material: Cast iron or Plastic with threads setscrews or another device.
   9. Frame and Cover Material and Finish: Nickel-bronze
   10. Frame and Cover Shape: Round.
   11. Top Loading Classification: Medium Duty.
   12. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:
   1. Standard: ASME A112.36.2M. Include wall access.
   2. Size: Same as connected drainage piping.
   3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
   4. Closure Plug:
      a. Brass.
      b. Countersunk head.
      c. Drilled and threaded for cover attachment screw.
      d. Size: Same as or not more than one size smaller than cleanout size.
   5. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
   6. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. By roofing contractor

a. Open-Top Vent Cap: Without cap.

b. Low-Silhouette Vent Cap: With vandal-proof vent cap.

c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.4 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Standard: UL 1479 assembly of sleeve-and-stack fitting with firestopping plug.

2. Size: Same as connected soil, waste, or vent stack.

3. Sleeve: Molded-PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

4. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.

5. Special Coating: Corrosion resistant on interior of fittings.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564 rubber gaskets.

2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.

2. Size: Same as connected waste piping.

a. NPS 2: 4-inch- minimum water seal.

b. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.

2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.

2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
   1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
   2. Locate at each change in direction of piping greater than 45 degrees.
   3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
   4. Locate at base of each vertical soil and waste stack.
B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
D. Assemble open drain fittings and install with top of hub 2 inches above floor.
E. Install deep-seal traps on floor drains and other waste outlets.
F. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
   2. Size: Same as floor drain inlet.
G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
H. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.
I. Retain first paragraph below for freezing climates. These units may be used to prevent frost closure instead of increasing vent size if permitted by authorities having jurisdiction.
J. Install blocking reinforcement for wall-mounting-type specialties.
K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections, and prepare test reports.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

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SECTION 221319.13

SANITARY DRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Floor drains.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene styrene.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene.

D. PE: Polyethylene.

E. PP: Polypropylene.

F. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Standard: ASME A112.6.3.
2. Pattern: Floor drain.
3. Body Material: Gray iron.
4. Seepage Flange: Required.
5. Anchor Flange: Not required.
6. Clamping Device: Not required.
7. Outlet: Bottom.
8. Coating on Interior and Exposed Exterior Surfaces: Not required.
9. Sediment Bucket: Not required.
10. Top or Strainer Material: Nickel bronze.
11. Top of Body and Strainer Finish: Nickel bronze.

12. Top Shape: Round.
13. Dimensions of Top or Strainer:6 inch.
14. Top Loading Classification: Light Duty
15. Funnel: Not required.
16. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
17. Trap Material: Cast iron or PVC.
18. Trap Pattern: Deep-seal P-trap.
19. Trap Features: Trap-seal primer valve drain connection.

B. PVC Decontamination Floor Drains:
1. Standard: ASME A112.6.3.
2. Pattern: Floor drain.
3. Body Material: PVC.
4. Seepage Flange: Required.
5. Anchor Flange: Not required.
6. Clamping Device: Not required.
7. Outlet: Bottom.
8. Coating on Interior and Exposed Exterior Surfaces: Not required.
9. Sediment Bucket: Not required.
10. Top or Strainer Material: Stainless steel.
11. Top of Body and Strainer Finish: PVC.
12. Top Shape: Round.
13. Dimensions of Top or Strainer:6 inch.
14. Top Loading Classification: Light Duty
15. Funnel: Not required.
16. Inlet Fitting: PVC, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.

C. PVC Decontamination Trench Drains:
1. Standard: ASME A112.6.3.
2. Pattern: Floor drain.
3. Body Material: PVC.
4. Seepage Flange: Required.
5. Anchor Flange: Not required.
6. Clamping Device: Not required.
7. Outlet: Bottom.

8. Coating on Interior and Exposed Exterior Surfaces: Not required.
9. Sediment Bucket: Not required.
10. Top or Strainer Material: Stainless steel.
11. Top of Body and Strainer Finish: PVC.
12. Top Shape: Round.
13. Dimensions of Top or Strainer:6 inch.
14. Top Loading Classification: Light Duty
15. Funnel: Not required.
16. Inlet Fitting: PVC, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radius:
a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
a. Maintain integrity of waterproof membranes where penetrated.
5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

B. Install open drain fittings with top of hub 2 inches above floor.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Install piping adjacent to equipment to allow service and maintenance.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

SECTION 221414

STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hubless, cast-iron soil pipe and fittings.
2. ABS pipe and fittings.
3. PVC pipe and fittings.
4. Specialty pipe fittings.
5. Encasement for underground metal piping.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Hubless, cast-iron soil pipe and fittings.
2. ABS pipe and fittings.
3. PVC pipe and fittings.
4. Specialty pipe fittings.

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings: For controlled-flow roof drainage system. Include calculations, plans, sections, elevations, and details.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and elevations, or Building Information Model (BIM) drawn to scale, showing items described in this Section and coordinated with all building trades.

B. Seismic Qualification Certificates: For storm drainage piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certificate is based and their installation requirements.

C. Field Quality-Control Reports: Inspection reports signed by authorities having jurisdiction.

1.4 QUALITY ASSURANCE

A. Provide materials bearing label, stamp, or other markings of specified testing agency.

1.5 WARRANTY

A. Listed manufacturers to provide labeling and warranty of their respective products

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation are to be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Storm Drainage Piping: **10-foot head of water**.

B. Seismic Performance: Storm drainage piping and support and installation to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 220548.13 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully functional after the seismic event."
2. Component Importance Factor: 1.0.

2.2 PIPING MATERIALS

A. Piping materials to bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Standards: ASTM A888 and CISPI 301.

B. Cast-Iron, Hubless-Piping Couplings:

1. Standard: ASTM A1056.
2. Description: Two-piece ASTM A48/A48M, cast-iron housing; stainless steel bolts and nuts; and ASTM C564, rubber sleeve with integral, center pipe stop.

C. Cast-Iron Flanges: ASME B16.1, Class 125.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.4 ABS PIPE AND FITTINGS

A. ABS Pipe:

1. NSF Marking: Comply with NSF 14 for plastic piping components. Include "NSF-dwv" marking for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.
2. Solid-Wall ABS Pipe: ASTM D2661, Schedule 40.
3. Cellular-Core ABS Pipe: ASTM F1488, Schedule 40.

B. ABS Socket Fittings:

1. Standard: ASTM D2661, made in accordance with ASTM D3311, drain, waste, and vent

patterns.

2. NSF Marking: Comply with NSF 14 for plastic piping components. Include "NSF-dwv" marking for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.

C. Solvent Cement: ASTM D2235.

1. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
2. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
3. Solvent cement shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.5 PVC PIPE AND FITTINGS

A. PVC Pipe:

1. NSF Marking: Comply with NSF 14 for plastic piping components. Include marking with "NSF-dwv" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.
2. Solid-Wall PVC Pipe: ASTM D2665 drain, waste, and vent.
3. Cellular-Core PVC Pipe: ASTM F891, Schedule 40.

B. PVC Socket Fittings:

1. Standard: ASTM D2665, made in accordance with ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
2. NSF Marking: Comply with NSF 14 for plastic piping components. Include marking with "NSF-dwv" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.

C. Adhesive Primer: ASTM F656.

1. Adhesive primer shall have a VOC content of 550 g/L or less.
2. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.

4. Adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.

D. Solvent Cement: ASTM D2564.

1. Solvent cement shall have a VOC content of 510 g/L or less.

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections of same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Unshielded, Nonpressure Transition Couplings:
   a. Standard: ASTM C1173.
   b. Description: Elastomeric sleeve, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. Sleeve Materials:
      1) For Cast-Iron Soil Pipes: ASTM C564 rubber.
      2) For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926 PVC.
      3) For Dissimilar Pipes: ASTM D5926 PVC or other material compatible with pipe materials being joined.
4. Shielded, Nonpressure Transition Couplings:
   a. Standard: ASTM C1460.
   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. End Connections: Same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

B. Install piping as indicated unless deviations from layout are approved on coordination drawings.

C. Install piping in concealed locations.

1. Piping installed in equipment rooms, service areas, and where indicated may be

exposed.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

L. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.

1. Do not change direction of flow more than 90 degrees.
2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
    a. Reducing size of drainage piping in direction of flow is prohibited.

M. Lay buried building piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

N. Install piping at the following minimum slopes unless otherwise indicated.

1. Building Storm Drain: 1/4 inch per foot downward in direction of flow for piping NPS 3 and smaller; 1/8 inch per foot downward in direction of flow for piping NPS 4 and larger.
2. Horizontal Storm Drainage Piping: 1/4 inch per foot downward in direction of flow.

O. Install cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Ch IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping in accordance with ASTM A674 or AWWA C105/A 21.5.

P. Install aboveground ABS piping in accordance with ASTM D2661.

Q. Install aboveground PVC piping in accordance with ASTM D2665.

R. Install underground ABS and PVC piping in accordance with ASTM D2321.

S. Install engineered controlled-flow drain specialties and storm drainage piping in locations indicated.

1. Install encasement on piping in accordance with ASTM A674 or AWWA C105/A 21.5.

T. Install force mains at elevations indicated.

U. Plumbing Specialties:

1. Install backwater valves in storm drainage gravity-flow piping.
   a. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."
2. Install cleanouts in storm drainage gravity-flow piping in accessible locations.
   a. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
   b. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
3. Install drains in storm drainage gravity-flow piping.
   a. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."

V. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

W. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220500 "Common Work Results for Plumbing."

X. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220500 "Common Work Results for Plumbing."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220500 "Common Work Results for Plumbing."

3.2 INSTALLATION OF SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Aboveground Force-Main Piping: Fitting-type transition couplings.

3.3 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel > pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.

3. Install stainless steel pipe support clamps for vertical piping in corrosive environments.
4. Vertical Piping: MSS Type 8 or Type 42, clamps.
5. Install individual, straight, horizontal piping runs:
   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
6. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
7. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install hangers for cast-iron piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

D. Install hangers for ABS and PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

F. Support vertical cast-iron piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent, but as a minimum at base and at each floor.

G. Support vertical ABS and PVC piping with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.4 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test storm drainage piping in accordance with procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
   a. If testing is performed in segments, submit separate report for each test, complete

with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.
   a. Expose work that was covered or concealed before it was tested.
3. Test Procedure:
   a. Test storm drainage piping on completion of roughing-in.
   b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
   c. From 15 minutes before inspection starts until completion of inspection, water level must not drop.
   d. Inspect joints for leaks.
4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.
   a. Expose work that was covered or concealed before it was tested.
2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.
   a. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.5 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground storm drainage piping NPS 6 and smaller is to be any of the following:
1. Service weight, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Copper Type DWV tube, copper drainage fittings, and soldered joints.
5. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
6. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

C. Aboveground, storm drainage piping NPS 8 and larger is to be any of the following:

1. Service weight, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
3. Galvanized-steel pipe, drainage fittings, and threaded joints.
4. Copper Type DWV tube, copper drainage fittings, and soldered joints.
5. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

D. Underground storm drainage piping NPS 6 and smaller shall be any of the following:

1. Service weight, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; [CISPI,] [heavy-duty,] [cast-iron,] hubless-piping couplings; and coupled joints.
3. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
4. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

E. Underground, storm drainage piping NPS 8 and larger is to be [any of] the following:

1. Service weight, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty cast-iron, hubless-piping couplings; and coupled joints.
3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. Cellular-core, sewer and drain series, PVC pipe; PVC socket fittings; and solvent-cemented joints.

END OF SECTION 221414

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SECTION 221423

STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-purpose roof drains.
2. Promenade roof drains.
3. Deck roof drains
4. Miscellaneous storm drainage piping specialties.
5. Cleanouts.
6. Backwater valves.
7. Trench drains.
8. Concrete trench drain-forming system.
9. Polymer-concrete channel drainage system.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.

1.3 QUALITY ASSURANCE

A. Provide drainage piping specialties are to bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 GENERAL-PURPOSE ROOF DRAINS

A. Cast-Iron Roof Drains:

1. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
   a. Source Limitations: Obtain cast-iron roof drains from single manufacturer.
   b. Standard: ASME A112.6.4.
   c. Body Material: Cast iron.
   d. Dimension of Body: Nominal 14-to 16-inchdiameter.
   e. Dome Material: Aluminum.
   f. Main roof drain and integral overflow roof drain.
   g. Combination flashing ring and gravel stop.
   h. Outlet: Bottom.
   i. Outlet Type: No-hub.
   j. Options:
      1) Flow-control weirs.
      2) Extension collars.

3) Underdeck clamp.
4) Expansion joint.
5) Sump receiver plate.
6) Vandal-proof dome.

B. Plastic Roof Drains:
1. Plastic General-Purpose Roof Drains:
a. Source Limitations: Obtain plastic general-purpose roof drains from single manufacturer.
b. Standard: ASME A112.6.4.
c. Body Material: ABS PVC
d. Main roof drain and integral overflow roof drain.
e. Dome Material: Aluminum.
f. Outlet: Bottom.
g. Options:
1) Combination flashing ring and gravel stop.
2) Extension collars.
3) Underdeck clamp.
4) Expansion joint.
5) Sump receiver plate.
6) Vandal-proof dome.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Boots:
1. Source Limitations: Obtain downspout boots from single manufacturer.
2. Description: Manufactured, ASTM A48/A48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 outlet; and shop-applied bituminous coating.
3. Size: Inlet size to match downspout and NPS 4 outlet.

B. Metal Downspout Nozzles:
1. Source Limitations: Obtain metal downspout nozzles from single manufacturer.
2. Description: Nozzle with wall flange and mounting holes to cover rough opening and serve as anchor.
3. Size: Same as connected downspout.
4. Material: Cast bronze or nickel bronze nozzle and flange.
5. Piping Connection Type: No-hub or slip on.
6. Finish: Cast.
7. Opening Protection: Birdscreen

C. Polymer Downspout Nozzles:

1. Source Limitations: Obtain polymer downspout nozzles from single manufacturer.
2. Description: Nozzle with wall flange and mounting holes to cover rough opening and serve as anchor.
3. Size: Same as connected downspout.
4. Material: High-impact, marine-grade polymer.
5. Piping Connection Type: Solvent welded.
6. Finish: Simulated oil-rubbed bronze.

2.3 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Cast-Iron Exposed Cleanouts:
   a. Source Limitations: Obtain cast-iron exposed cleanouts from
   b. Standard: ASME A112.36.2M.
   c. Size: Same as connected branch.
   d. Body Material: No-hub, cast-iron soil pipe test tee as required to match connected piping.
   e. Closure: Brass, plastic plug.
   f. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.
2. Cast-Iron Wall Cleanouts:
   a. Source Limitations: Obtain cast-iron wall cleanouts from single manufacturer.
   b. Standard: ASME A112.36.2M. Include wall access.
   c. Size: Same as connected drainage piping.
   d. Body No-hub, cast-iron soil pipe test tee as required to match connected piping.
   e. Closure Plug:
      1) Material: Brass.
      2) Head: Countersunk.
      3) Drilled and threaded for cover attachment screw.
      4) Size: Same as, or not more than, one size smaller than cleanout size.
   f. Wall-Access Cover Plate: Round, flat, chrome-plated brass cover plate with screw.
3. Cast-Iron Test Tees:
   a. Source Limitations: Obtain cast-iron test tees from single manufacturer.
   b. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
   c. Size: Same as connected drainage piping.
   d. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
   e. Closure Plug: Countersunk brass.

f. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

B. Plastic Cleanouts:

1. Plastic Cleanouts:

a. Source Limitations: Obtain plastic cleanouts from single manufacturer.

b. Size: Same as connected branch.

c. Body Material: PVC ABS.

d. Closure Plug: PVC ABS.

e. Type: Wall and floor.

f. Frame and Cover Material and Finish: Polished bronze.

g. Frame and Cover Shape: Round.

h. Riser: Drainage pipe fitting and riser to cleanout of same material as drainage piping.

2.4 CONCRETE TRENCH DRAIN-FORMING SYSTEM – NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION OF STORM DRAINAGE PIPING SPECIALTIES

A. Install roof drains in accordance with roof membrane manufacturer's written installation instructions at low points of roof areas.

1. Install flashing collar or flange of roof drain to maintain integrity of waterproof membranes where penetrated.

2. Install expansion joints, if indicated, in roof drain outlets.

3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. Install downspout boots at grade with top 18 inches above grade. Secure to building wall.

D. Install downspout nozzles at exposed bottom of conductors where they spill onto grade.

E. Install cleanouts in aboveground piping and building drain piping in accordance with the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.

2. Locate cleanouts at each change in direction of piping greater than 45 degrees.

3. Locate cleanouts at minimum intervals of 50 ft. for piping NPS 4 and smaller and 100 ft. for larger piping.

4. Locate cleanouts at base of each vertical storm piping conductor.

F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

H. Install horizontal backwater valves in floor with cover flush with floor.

I. Install drain-outlet backwater valves in outlet of drains.

J. Install test tees in vertical conductors and near floor.

K. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

L. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.

M. Assemble channel drainage system components in accordance with manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

N. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

1. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 INSTALLATION OF FLASHING

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

END OF SECTION 221423

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SECTION 223300

ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Commercial, electric, storage, domestic-water heaters.
2. Domestic-water heater accessories.

1.3 PERFORMANCE REQUIREMENTS – NOT USED

1.4 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For commercial domestic-water heaters, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Product Certificates: For each type of commercial, electric, domestic-water heater, from manufacturer.

C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

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

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.8 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
    a. Structural failures including storage tank and supports.
    b. Faulty operation of controls.
    c. Deterioration of metals, metal finishes, and other materials beyond normal use.
2. Warranty Periods: From date of Substantial Completion.
    a. Commercial, Electric, Storage, Domestic-Water Heaters:
        1) Storage Tank: Five years.
        2) Controls and Other Components: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Domestic-Water Booster Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Rheem Manufacturing Company.
    b. A.O. Smith Corporation.
    c. State Water Heaters.
2. Standard: UL 1453.

3. Tank Construction: Corrosion-resistant metal or steel.
    a. Tappings: ASME B1.20.1 pipe thread.
    b. Pressure Rating: 150 psig (1035 kPa).
    c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.
4. Factory-Installed Tank Appurtenances:
    a. Anode Rod: Replaceable magnesium.
    b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
    c. Insulation: Comply with ASHRAE/IESNA 90.1.
    d. Jacket: Rectangular shaped, with stainless-steel front panel, unless otherwise indicated.
    e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
    f. Temperature Control: Adjustable thermostat, to setting of at least 180 deg F (82 deg C).
    g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
    h. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valve. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
    i. Gages: Combination temperature-and-pressure type or separate thermometer and pressure gage.
5. Special Requirements: NSF 5 construction with legs for floor installation.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. AMTROL, Inc.
    b. State Industries.
    c. TACO Comfort Solutions, Inc.
2. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction:

a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.

b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

c. Air-Charging Valve: Factory installed.

4. Capacity and Characteristics:

a. Working-Pressure Rating: 150 psig (1035 kPa).

b. Capacity: 4 gallon of acceptance.

c. Air Precharge Pressure: Factory Set.

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig- (172.5-kPa-) maximum outlet pressure unless otherwise indicated.

F. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

G. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

I. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for wall mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 36 inches (914 mm) above the floor.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting

and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete".

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Anchor domestic-water heaters to substrate.

B. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

C. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

D. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install water heater drain piping as indirect waste to spill by positive are gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 “Domestic Water Piping Specialties.”

F. Fill electric, domestic-water heaters with water.

G. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain commercial, electric, domestic-water heaters.

END OF SECTION 223300

SECTION 224213.13

COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Water closets.
2. Flushometer valves.
3. Toilet seats.
4. Supports.

1.3 DEFINITIONS

A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer-Valve Repair Kits: One of each type.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

A. Water Closets P-101 Floor mounted, ADA rated, bottom outlet, sensor flushometer valve.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. American Standard.

b. Kohler Co.
c. TOTO USA, INC.
d. Sloan.

2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed
9. Actuator: Solenoid complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
10. Trip Mechanism: Hard-wired electronic sensor complying with UL 1951, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
11. Consumption: 1.6 gal. (6 L) per flush.
12. Minimum Inlet: NPS 1 (DN 25).

B. Water Closets P-102 Floor mounted, ADA rated, bottom outlet, manual flushometer valve with bed pan lugs and bed pan washer.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. American Standard.
   b. Kohler Co.
   c. TOTO USA, INC.
   d. Sloan.
2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed
9. Actuator: Manual actuated flush valve.
10. Provide with bed pan washer.
11. Consumption: 1.6 gal. (6 L) per flush.

C. Water Closets P-102A Bariatric and ADA rated, floor mounted, welded14 gauge 304 stainless steel body, bottom outlet, manual flushometer valve with bed pan lugs and bed pan washer.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Whitehall Manufacturing
2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed
9. Actuator: Manual actuated flush valve.
10. Provide with bed pan washer.
11. Consumption: 1.6 gal. (6 L) per flush.
12. Finish: White powder coat finish.
13. Weight Rating: 2000 lbs.

2.2 TOILET SEATS

A. Toilet Seats for P-101 and P-102.

1. Standard: IAPMO/ANSI Z124.5.
2. Material: Plastic.
3. Type: Commercial (Standard)
4. Shape: Elongated rim, open
5. Hinge: Self-sustaining, check.
6. Hinge Material: Noncorroding metal.
7. Seat Cover: Not required.
8. Color: White

B. Toilet Seats for P-102A.

1. Standard: IAPMO/ANSI Z124.5.
2. Material: Plastic.
3. Type: Bariatric
4. Shape: Elongated rim, open
5. Hinge: Self-sustaining, check.
6. Hinge Material: Noncorroding metal.

7. Weight rating: 1,200 lbs.
8. Color: White

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.
B. Examine walls and floors for suitable conditions where water closets will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Water-Closet Installation:
   1. Install level and plumb according to roughing-in drawings.
   2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
   3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
B. Support Installation:
   1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
C. Install toilet seats on water closets.
D. Wall Flange and Escutcheon Installation:
   1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
   2. Install deep-pattern escutcheons if required to conceal protruding fittings.
   3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
E. Joint Sealing:
   1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
   2. Match sealant color to water-closet color.
   3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

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SECTION 224216.13

COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Lavatories.
2. Faucets.
3. Supply fittings.
4. Waste fittings.
5. Supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Servicing and adjustments of automatic faucets.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

A. Lavatory Vitreous china, wall mounted, with back.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. American Standard.
   b. Kohler Co.
   c. Sloan Valve Company.
   d. Zurn Industries, LLC.
2. Fixture:
   a. Standard: ASME A112.19.2/CSA B45.1.
   b. Type: For wall hanging.
   c. Nominal Size: 20x18
   d. Faucet-Hole Punching: One hole
   e. Faucet-Hole Location: Top.
   f. Color: White
   g. Mounting Material: Concealed arm carrier. 250 lbs. weight rating.
3. Faucet: Solid-Brass, Automatically Operated Lavatory Faucets.
4. Support: Type II, concealed-arm lavatory carrier with escutcheons Include rectangular, steel uprights.
5. Lavatory Mounting Height: Handicapped according to ICC A117.1.

B. Lavatory Vitreous china, wall mounted.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. American Standard.
   b. Kohler Co.
   c. Sloan Valve Company.
   d. Zurn Industries, LLC.
2. Fixture:
   a. Standard: ASME A112.19.2/CSA B45.1.
   b. Type: For wall hanging.
   c. Nominal Size: Oval, 20x18.
   d. Faucet-Hole Punching: Three holes, 4-inch (102-mm) centers.

e. Faucet-Hole Location: Top.
f. Color: White
g. Mounting Material: Concealed arm carrier. 250 lbs. weight rating.

3. Faucet: Solid Brass, Manually Operated Faucets.
4. Support: Type II, concealed-arm lavatory carrier with escutcheons. Include rectangular, steel uprights.
5. Lavatory Mounting Height: Handicapped/elderly according to ICC A117.1.

C. Bariatric Lavatory Stainless Steel, wall mounted, with back.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Whitehall
2. Fixture:
   a. Standard: ASME A112.19.2/CSA B45.1.
   b. Type: For wall hanging.
   c. Nominal Size: D shape bowl
   d. Faucet-Hole Punching: Three holes, 4-inch (102-mm) centers.
   e. Faucet-Hole Location: Top.
   f. Color: White powder coat finish.
   g. Mounting Material: 1000 lbs rated wall carrier.
3. Faucet: Solid-Brass, Automatically Operated Lavatory Faucets.
4. Support: Type II, concealed-arm lavatory carrier with escutcheons Include rectangular, steel uprights.
5. Lavatory Mounting Height: Handicapped according to ICC A117.1.

2.2 SOLID-BRASS, MANUALLY OPERATED FAUCETS

A. NSF Standard: Comply with NSF 372 for faucet materials that will be in contact with potable water.

B. Lavatory Faucets Manual-type, single-control mixing, solid-brass valve.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. American Standard.
   b. Chicago Faucets; Geberit Company.
   c. Kohler Co.
   d. Sloan Valve Company.

e. T&S Brass and Bronze Works, Inc.
f. Zurn Industries, LLC.

2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
4. Body Type: Centerset
5. Body Material: Commercial, solid brass.
6. Finish: Polished chrome plate
7. Maximum Flow Rate: 0.5 gpm (1.5 L/min)
8. Mounting Type: Deck, exposed
9. Valve Handle(s): Elbow, 6 inches (152 mm).
10. Spout: Rigid, gooseneck type.
11. Spout Outlet: Laminar flow
12. Operation: Compression, manual

2.3 SOLID-BRASS, AUTOMATICALLY OPERATED LAVATORY FAUCETS

A. NSF Standard: Comply with NSF 372 for faucet materials that will be in contact with potable water.

B. Lavatory Faucets: Automatic-type, hard-wired, electronic-sensor-operated, mixing solid-brass valve.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. American Standard.
   b. Chicago Faucets; Geberit Company.
   c. Kohler Co.
   d. Sloan Valve Company.
   e. T&S Brass and Bronze Works, Inc.
   f. Zurn Industries, LLC.
2. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
5. Body Type: Single hole
6. Body Material: Commercial solid brass.

7. Finish: Polished chrome plate
8. Maximum Flow Rate: 0.5 gpm (1.5 L/min)
9. Mounting Type: Deck, concealed.
10. Spout: Rigid, gooseneck type.
11. Spout Outlet: Laminar flow

2.4 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

A. NSF Standard: Comply with NSF 372 for faucet-spout-outlet materials that will be in contact with potable water.

B. Description: Chrome-plated-brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.5 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 372 for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Wheel handle

F. Risers:

1. NPS 3/8 (DN 10)
2. ASME A112.18.6, braided- or corrugated-stainless-steel, flexible hose riser.

2.6 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 (DN 32) offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/4 (DN 32).
2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall and chrome-plated, brass or steel wall flange.
3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch- (0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.

2.7 SUPPORTS

A. Type II Lavatory Carrier:

1. Standard: ASME A112.6.1M.

B. Type III Lavatory Carrier:
   1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.
B. Examine counters and walls for suitable conditions where lavatories will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install lavatories level and plumb according to roughing-in drawings.
B. Install supports, affixed to building substrate, for wall-mounted lavatories.
C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.
B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

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SECTION 224216.16

COMMERCIAL SINKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Service basins.
2. Exam sinks.
3. Sink faucets.
4. Laminar-flow, faucet-spout outlets.
5. Supports.
6. Supply fittings.
7. Waste fittings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For sinks to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 SERVICE BASINS

A. Service Basins P-5 Terrazzo, floor mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Fiat.

b. Florestone Products Co., Inc.

2. Fixture:
    a. Standard: IAPMO PS 99.
    b. Shape: Square
    c. Nominal Size: 28 by 28 inches (610 by 610 mm)
    d. Height: 12 inches (305 mm) In "Tiling Flange" Subparagraph below, verify availability if required and indicate side(s) if basin is rectangular.
    e. Tiling Flange: On two sides.
    f. Rim Guard: all top surfaces.
    g. Color: Not applicable
    h. Drain: Grid with NPS 3 (DN 80) outlet.
3. Mounting: On floor and flush to wall.
4. Faucet: Wall mounted with pale hook and integral check stops.

2.2 SINK FAUCETS

A. NSF Standard: Comply with NSF 372 for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Manual type, two lever handle mixing valve.

1. Commercial, Solid-Brass Faucets Commercial, Solid-Brass Faucets Type 1:
    a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    b. American Standard.
    c. Bradley Corporation.
    d. Chicago Faucets; Geberit Company.
    e. Kohler Co.
    f. T&S Brass and Bronze Works, Inc.
    g. Zurn Industries, LLC.
2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
4. Body Type: Widespread
5. Body Material: Commercial, solid brass
6. Finish: Polished chrome plate Maximum Flow Rate: 2.2 gpm (8.3 L/min)
7. Handle(s): Wrist blade, 6 inches (102 mm)
8. Mounting Type: Deck, exposed
9. Spout Type: Rigid gooseneck
10. Vacuum Breaker: for hose outlet.

11. Spout Outlet: Laminar flow.

2.3 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

A. NSF Standard: Comply with NSF 372 for faucet-spout-outlet materials that will be in contact with potable water.

B. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.4 SUPPORTS

A. Type II Sink Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Jay R. Smith Mfg Co; a division of Morris Group International.
   b. Josam Company.
   c. Zurn Industries, LLC.
2. Standard: ASME A112.6.1M.

2.5 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 372 for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation Wheel handle

F. Risers:

1. NPS 3/8 (DN 10)
2. ASME A112.18.6, braided or corrugated stainless-steel flexible hose

2.6 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/2 (DN 40) offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2 (DN 40).
2. Material: Chrome-plated,(0.83-mm-) thick brass tube to wall; and chrome-plated brass wall flange.

3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch- (0.30-mm-) thick stainless-steel tube to wall; and stainless-steel wall flange.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.

B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.

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

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.

D. Set floor-mounted sinks in leveling bed of cement grout.

E. Install water-supply piping with stop on each supply to each sink faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

2. Install stops in locations where they can be easily reached for operation.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

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SECTION 224500

EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Eyewash equipment.
2. Supplemental equipment.
3. Water-tempering equipment.

1.3 DEFINITIONS

A. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.

B. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ISEA Standard: Comply with ISEA Z358.1.

B. NSF Standard: Comply with NSF 61 and NSF 372, for fixture materials that will be in contact with potable water.

C. Regulatory Requirements: Comply with requirements in ICC A117.1; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. Sink, Swivel-Type, Plumbed Eyewash Unit:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Acorn Safety.
   b. Bradley Corporation.
   c. Guardian Equipment Co.
   d. Speakman Company.
2. Capacity: Not less than 0.4 gpm for at least 15 minutes.
3. Supply Piping: NPS 1/2 chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
4. Control-Valve Actuator: Movement of spray-head assembly to position over sink.
5. Spray-Head Assembly: Two spray heads with offset piping.
6. Mounting: Deck next to sink.

2.2 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment – TV-2:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Armstrong International, Inc.
   b. Bradley Corporation.
   c. Guardian Equipment Co.
   d. Leonard Valve Company.
   e. POWERS; A WATTS Brand.
2. Description: Factory-fabricated equipment with thermostatic mixing valve.
   a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
   b. Supply Connections: For hot and cold water.

c. Accessories: Output temperature gauge, output pressure gauge internal shut-off valves.

2.3 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

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

3.2 INSTALLATION OF EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of the equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment.

G. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

H. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

I. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 CONNECTIONS

A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

C. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

E. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION 224500

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SECTION 224716

PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pressure water coolers and related components.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of pressure water cooler.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Pressure Water Coolers : Wall mounted, wheelchair accessible.

1. Manufacturers: Oasis, Elkay, Halsey Taylor
2. Standards:
   a. Comply with NSF 61 Annex G.
   b. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
3. Cabinet: Bi-level with two attached cabinets and with a bi-level skirt kit, stainless steel top.
4. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
5. Control: Push pad.
6. Drain: Grid with NPS 1-1/4 tailpiece.
7. Supply: NPS 3/8 with shutoff valve.

8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
9. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
10. Provide with bottle filler.
11. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
    a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
12. Capacities and Characteristics:
    a. Cooled Water: 8 gph.
    b. Ambient-Air Temperature: 90 deg F.
    c. Inlet-Water Temperature: 80 deg F.
    d. Cooled-Water Temperature: 50 deg F.
    e. Electrical Characteristics:
        1) Volts: 120-V ac.
        2) Phase: Single.
        3) Hertz: 60.
        4) Full-Load Amperes: 5.
        5) Motor HP: 1/4
13. Water Cooler Mounting Height: Handicapped/elderly according to ICC A117.1.
14. Provide with wall carrier.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.
B. Examine walls and floors for suitable conditions where fixtures will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
B. Set freestanding pressure water coolers on floor.
C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

D. Install mounting frames, affixed to building construction, and attach recessed, pressure water coolers to mounting frames.

E. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

F. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

H. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball or gate shutoff valve on water supply to each fixture. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224716

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SECTION 226113

COMPRESSED-AIR PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Medical compressed-air piping, designated "medical air."

B. Related Requirements:

1. Section 226400 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.3 DEFINITIONS

A. Medical compressed-air piping systems include medical air, dental air, instrument air, and medical laboratory air.

B. Nonmedical compressed-air piping systems include laboratory air piping systems.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Certificates: For medical compressed-air manifolds, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Material Certificates: Signed by Installer certifying that medical compressed-air piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.

D. Brazing certificates.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical compressed-air pressure outlets.

a. Medical Air: Equal to 10 percent of amount installed, but no fewer than 5 units.

2. D.I.S.S. Service Connections: Furnish complete medical compressed-air pressure outlets complying with CGA V-5.

a. Medical Air D.I.S.S. No. 1160: Equal to 10 percent of amount installed, but no fewer than 5 units.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Air Piping Systems for Healthcare Facilities: According to ASSE Standard #6010 for medical-gas-system installers.

2. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Medical air operating at 50 to 55 psig.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Medical compressed-air manifolds shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the manifold will remain in place without separation of any parts when subjected to the seismic forces specified and the manifold will be fully operational after the seismic event."

2.3 PIPES, TUBES, AND FITTINGS

A. Comply with NFPA 99 for medical air piping materials.

B. Copper Medical Gas Tube: ASTM B 819, Type K and Type L, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and in blue for Type L tube.

C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.

1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness, full-face type.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

F. Flexible Pipe Connectors:

1. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   a. Working-Pressure Rating: 200 psig minimum.
   b. End Connections: Plain-end copper tube.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.5 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.

1. Zone-Valve Boxes:
   a. Steel Box with Aluminum Cover:
      1) As manufactured by Amico or Approved Equal
   b. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.
      1) Interior Finish: Factory-applied white enamel.
      2) Cover Plate: Aluminum with frangible or removable windows.

3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

C. Ball Valves:

1. Standard: MSS SP-110.
2. Description: Three-piece body, brass or bronze.
3. Pressure Rating: 300 psig minimum.
4. Ball: Full-port, chrome-plated brass.
5. Seats: PTFE or TFE.
6. Handle: Lever type
7. Stem: Blowout proof with PTFE or TFE seal.
8. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions and manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

D. Check Valves:

1. Description: In-line pattern, bronze.
2. Pressure Rating: 300 psig minimum.
3. Operation: Spring loaded.
4. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

E. Safety Valves:

1. Bronze body.
2. ASME-construction, poppet, pressure-relief type.
3. Settings to match system requirements.

F. Pressure Regulators:

1. Bronze body and trim.
2. Spring-loaded, diaphragm-operated, relieving type.
3. Manual pressure-setting adjustment.
4. Rated for 250-psig minimum inlet pressure.
5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

2.6 MEDICAL COMPRESSED-AIR SERVICE CONNECTIONS

A. General Requirements for Medical Compressed-Air Service Connections:

1. Suitable for specific medical air pressure and service listed.
2. Include roughing-in assemblies, finishing assemblies, and cover plates.
3. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate.

4. Recessed-type units made for concealed piping unless otherwise indicated.

B. Roughing-in Assembly:
1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
3. Double seals that will prevent air leakage.
4. ASTM B 819, NPS 3/8 copper outlet tube brazed to valve with service marking and tube-end dust cap.

C. Finishing Assembly:
1. Brass housing with primary check valve.
2. Double seals that will prevent air leakage.
3. Cover plate with gas-service label.

D. Quick-Coupler Pressure Service Connections:
1. Outlets for medical air with noninterchangeable keyed indexing to prevent interchange between services.
2. Constructed to permit one-handed connection and removal of equipment.
3. With positive-locking ring that retains equipment stem in valve during use.

E. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
1. Medical Air: D.I.S.S. No. 1160.
2. Instrument Air: D.I.S.S. No. 1160.

F. Cover Plates:
1. One piece.
2. Aluminum or stainless steel.
3. Permanent, color-coded, identifying label matching corresponding service.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.

2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
   a. Scrub to ensure complete cleaning.
   b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Comply with NFPA 99 for installation of compressed-air piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install compressed-air piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

I. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install piping to permit valve servicing.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and for branch connections.

N. Install medical air piping to medical air service connections specified in this Section, to medical air service connections in equipment specified in Section 226313 "Gas Piping for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical air service.

O. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

P. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.

B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on compressed-air piping where reduced pressure is required.

3.4 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

D. Flanged Joints: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

3.5 COMPRESSED-AIR SERVICE COMPONENT INSTALLATION

A. Install compressed-air pressure control panel in walls. Attach to substrate.

B. Install compressed-air manifolds anchored to substrate.

C. Install compressed-air cylinders and connect to manifold piping.

D. Install compressed-air manifolds with seismic restraints as indicated.

E. Install compressed-air-cylinder wall storage racks attached to substrate.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Vertical Piping: MSS Type 8 or Type 42, clamps.

C. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.

2. Longer than 100 Feet: MSS Type 43, adjustable, roller hangers.

D. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

E. Base of Vertical Piping: MSS Type 52, spring hangers.

F. Support horizontal piping within 12 inches of each fitting and coupling.

G. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch-minimum rods.

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4: 60 inches with 3/8-inch rod.
2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
3. NPS 3/4: 84 inches with 3/8-inch rod.
4. NPS 1: 96 inches with 3/8-inch rod.
5. NPS 1-1/4: 108 inches with 3/8-inch rod.
6. NPS 1-1/2: 10 feet with 3/8-inch rod.
7. NPS 2: 11 feet with 3/8-inch rod.
8. NPS 2-1/2: 13 feet with 1/2-inch rod.

I. Install supports for vertical copper tubing every 10 feet.

3.7 IDENTIFICATION

A. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for medical compressed-air piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Medical Air: Black letters on yellow background.

3.8 FIELD QUALITY CONTROL FOR MEDICAL COMPRESSED-AIR PIPING IN HEALTHCARE FACILITIES

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections of medical compressed-air piping in healthcare facilities and to prepare test and inspection reports.

B. Tests and Inspections:

1. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of medical gas piping and medical vacuum piping systems.

2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
   a. Initial blowdown.
   b. Initial pressure test.
   c. Cross-connection test.
   d. Piping purge test.
   e. Standing pressure test for positive-pressure medical compressed-air piping.
   f. Repair leaks and retest until no leaks exist.
3. System Verification: Perform the following tests and inspections according to NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:
   a. Standing pressure test.
   b. Individual-pressurization or pressure-differential cross-connection test.
   c. Valve test.
   d. Master and area alarm tests.
   e. Piping purge test.
   f. Piping particulate test.
   g. Piping purity test.
   h. Final tie-in test.
   i. Operational pressure test.
   j. Medical air purity test.
   k. Verify correct labeling of equipment and components.
4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
   a. Inspections performed.
   b. Procedures, materials, and gases used.
   c. Test methods used.
   d. Results of tests.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.9 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.10 PIPING SCHEDULE

A. Connect new tubing to existing tubing with memory-metal couplings.

B. Flanges may be used where connection to flanged equipment is required.

C. Medical Air Piping except Instrument Air Piping Larger than NPS 3 and Operating at More Than 185 psig: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.11 VALVE SCHEDULE

A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B 819, copper-tube extensions.

B. Zone Valves: Ball valve with manufacturer-installed ASTM B 819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226113

SECTION 226213

VACUUM PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Medical-surgical vacuum piping, designated "medical vacuum."

B. Related Requirements:

1. Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities" for vacuum producers and accessories.
2. Section 226400 "Medical Gas Alarms" for vacuum piping alarms.

1.3 DEFINITIONS

A. Vacuum Piping Systems: Include medical vacuum.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Data: Certificates, for compressed-air manifolds, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Material Certificates: Signed by Installer, certifying that medical vacuum piping materials comply with requirements in NFPA 99 for medical vacuum systems.

D. Brazing certificates.

E. Field quality-control reports.

F. Source Quality Control Reports:

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical vacuum suction inlets.

a. Medical Vacuum: Equal to 10 percent of amount installed, but no fewer than 10 units.

b. WAGD: Equal to 10 percent of amount installed, but no fewer than 5 units.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Vacuum Piping Systems for Healthcare Facilities: In accordance with ASSE Standard #6010 and NFPA 99 for medical-gas-system installers.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel in accordance with ASSE Standard #6020 and NFPA 99 for medical-gas-system inspectors and ASSE Standard #6030 and NFPA 99 for medical-gas-system verifiers.

C. Brazing: Qualify processes and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," or AWS B2.2/B2.2M.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Medical vacuum operating at 18 in. Hg (380 mm Hg).

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Medical gas manifolds shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7

1. The term "withstand" means "the medical gas manifolds will remain in place without separation of any parts when subjected to the seismic forces specified.

2. Component Importance Factor is 1.5.

B. Comply with NFPA 99.

2.3 PIPES, TUBES, AND FITTINGS

A. Comply with NFPA 99 for medical vacuum piping materials.

B. Copper Medical Gas Tube: ASTM B819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or in accordance with CGA G-

4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue.

C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and sealed for medical gas service or in accordance with CGA G-4.1 for oxygen service.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.

1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
2. Flange Bolts and Nuts: ASME B18.2.1 carbon steel.

F. Flexible Pipe Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Flexicraft Industries.
   b. Metraflex Company (The).
2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   a. Working-Pressure Rating: 200 psig (1380 kPa) minimum.
   b. End Connections: Plain-end copper tube.

2.4 JOINING MATERIALS

A. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux in accordance with ASTM B813.

B. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.

C. Threaded-Joint Tape: PTFE.

2.5 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged in accordance with CGA G-4.1 for oxygen service.

1. Exception: Factory cleaning and bagging are not required for valves for WAGD service.

B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.

1. Zone-Valve Boxes:
   a. Steel Box with Aluminum Cover:
      1) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         a) Allied Healthcare Products Inc.
         b) Amico Corporation.

c) Beacon Medaes

b. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.

1) Interior Finish: Factory-applied white enamel.

2) Cover Plate: Aluminum with frangible or removable windows.

3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.

C. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Healthcare Products Inc.
   b. Amico Corporation.
   c. BeaconMedaes.
2. Standard: MSS SP-110.
3. Description: Three-piece body, brass or bronze.
4. Pressure Rating: 300 psig (2070 kPa) minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever type with locking device.
8. Stem: Blowout proof with PTFE or TFE seal.
9. Ends: manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension.

D. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Allied Healthcare Products Inc.
   b. Amico Corporation.
   c. BeaconMedaes.
   d. NIBCO INC.
2. Description: In-line pattern, bronze.
3. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Operation: Spring loaded.

5. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.

2.6 MEDICAL VACUUM SERVICE CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Allied Healthcare Products Inc.
   2. Amico Corporation.
   3. BeaconMedaes.

B. General Requirements for Medical Vacuum Service Connections:
   1. Suitable for specific medical vacuum service listed.
   2. Include roughing-in assemblies, finishing assemblies, and cover plates.
   3. Individual cover plates are not required if service connection is in multiple units or assembly with cover plate.
   4. Recessed-type units made for concealed piping unless otherwise indicated.

C. Roughing-in Assembly:
   1. Steel outlet box for recessed mounting and concealed piping.
   2. Brass-body inlet block.
   3. Seals that will prevent vacuum leakage.
   4. ASTM B819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

D. Finishing Assembly:
   1. Brass housing with primary check valve.
   2. Seals that will prevent vacuum leakage.
   3. Cover plate with gas-service label.

E. Quick-Coupler Suction Service Connections:
   1. Inlets for medical vacuum and WAGD with noninterchangeable keyed indexing to prevent interchange between services.
   2. Constructed to permit one-handed connection and removal of equipment.
   3. With positive-locking ring that retains equipment stem in valve during use.

F. D.I.S.S. Suction Service Connections:
   1. Inlets complying with CGA V-5.
   2. Threaded indexing to prevent interchange between services.
   3. Constructed to permit one-handed connection and removal of equipment.
   4. Medical Vacuum: CGA V-5, D.I.S.S. No. 1220.

G. Vacuum Bottle Brackets: One piece, with pattern and finish matching corresponding service cover plate.

H. Cover Plates:
1. One piece.
2. Stainless steel.
3. Permanent, color-coded, identifying label matching corresponding service.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Vacuum Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
1. Clean medical vacuum tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service in accordance with CGA G-4.1.
2. Wash medical vacuum tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.
a. Scrub to ensure complete cleaning.
b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

A. General Location and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, vacuum producer sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
B. Comply with NFPA 99 for installation of vacuum piping.
C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
F. Install piping adjacent to equipment and specialties to allow service and maintenance.
G. Install piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install piping to permit valve servicing.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and for branch connections. Extruded-tee branch outlets in copper tubing may be made where specified.

N. Install medical vacuum piping from medical vacuum service connections specified in this Section, to equipment specified in Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical vacuum service.

O. Install vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

P. Install vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.

Q. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

R. Install unions in copper vacuum tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from vacuum equipment and specialties.

B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Apply appropriate tape to external pipe threads.

D. Brazed Joints: Join copper tube and fittings in accordance with CDA's "Copper Tube Handbook," Ch. "Brazed Joints." Do not use flux. Continuously purge joint with oil-free dry nitrogen during brazing.

E. Soldered Joints: Apply ASTM B813, water-flushable flux to tube end. Join copper tube and fittings in accordance with ASTM B828.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Vertical Piping: MSS Type 8 or Type 42, clamps.

C. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

D. Base of Vertical Piping: MSS Type 52 spring hangers.

E. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

G. Support vertical runs of copper tubing to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 IDENTIFICATION

A. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for medical vacuum piping systems in accordance with NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Medical Vacuum: Black letters on white background.
2. WAGD: White letters on violet background.

3.7 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL VACUUM PIPING

A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.

2. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

D. Tests and Inspections:

1. Medical Vacuum Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum piping systems concurrently with tests, inspections, and certification of medical gas piping systems.

2. Preparation: Perform the following Installer tests in accordance with requirements in NFPA 99 and ASSE Standard #6010:

a. Initial blowdown.

b. Initial pressure test.

c. Cross-connection test.

d. Piping purge test.

e. Standing pressure test for vacuum systems.

f. Repair leaks and retest until no leaks exist.

3. System Verification: Perform the following tests and inspections in accordance with NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:

a. Standing pressure test.

b. Individual-pressurization or pressure-differential cross-connection test.

c. Valve test.

d. Master and area alarm tests.

e. Piping purge test.

f. Final tie-in test.

g. Operational vacuum test.

h. Verify correct labeling of equipment and components.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed, and certify report results. Include the following:

a. Inspections performed.

b. Procedures, materials, and gases used.

c. Test methods used.

d. Results of tests.

E. Piping will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 PIPING SCHEDULE

A. Medical Vacuum Piping: Use the following piping materials for each size range:

1. NPS 2 and Smaller: Copper medical gas tube, wrought-copper fittings, and brazed joints.

3.9 VALVE SCHEDULE

A. Shutoff Valves:

1. Copper Tubing: Copper-alloy ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

B. Zone Valves: Copper-alloy ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226213

SECTION 226219

VACUUM EQUIPMENT FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Rotary, sliding-vane vacuum pumps.

B. Related Requirements:

1. Section 226400 "Medical Gas Alarms" for vacuum equipment local alarms.

1.3 DEFINITIONS

A. Actual Air: Air delivered at vacuum producer inlet. Flow rate is air measured in acfm (actual L/s).

B. Medical Vacuum Equipment: Includes medical WAGD vacuum producers and accessories for healthcare facilities.

C. Standard Air: Free air at 68 deg F (20 deg C) and 1 atmosphere (29.92 in. Hg) before compression or expansion and measured in scfm (standard L/s).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For vacuum producers.

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Certificates: For vacuum producers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For vacuum equipment to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:
1. Medical Vacuum Equipment for Healthcare Facilities: Qualify installers according to ASSE 6010.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum equipment testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Vacuum producers and accessories shall withstand the effects of earthquake motions determined according to ASCE/SEI 7
1. The term "withstand" means "the vacuum producer and receiver or separator will remain in place without separation of any parts when subjected to the seismic forces specified
2. Component Importance Factor: 1.5

2.2 GENERAL REQUIREMENTS FOR VACUUM PUMPS

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

B. Comply with NFPA 99, "Health Care Facilities," for vacuum equipment and accessories for medical vacuum systems.

C. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.

D. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.

2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 120-V ac or less, using integral control power transformer.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
6. Automatic control switches to alternate lead-lag vacuum pumps for duplex vacuum pumps.
7. Instrumentation: Include vacuum pump inlet and receiver vacuum gages, hour meter, vacuum pump discharge-air and coolant temperature gages, and control transformer.
8. Alarm Signal Devices: For connection to alarm system to indicate when backup vacuum pump is operating.

E. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.
1. Interior Finish: Corrosion-resistant coating.
2. Accessories: Include vacuum relief valve, vacuum gage, and drain.

F. Mounting Frames: Fabricate base and attachment to vacuum pump and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 ROTARY, SLIDING-VANE VACUUM PUMPS

A. Oil-Free, Rotary, Sliding-Vane Vacuum Pumps:
1. Description: Packaged unit.
2. Vacuum Pump(s): Nonpulsating, oil-free, rotary, sliding-vane type.
a. Cleanable inlet screens.
3. Outlet silencers on discharge connections.

B. Capacities and Characteristics:
1. Vacuum Service: Medical vacuum.
2. Vacuum Pump(s): Two
3. Standard-Air Capacity of Each Vacuum Pump: 8 scfm free air.
4. Vacuum Required: 20 in. Hg (510 mm Hg)
5. Mounting: Tank mounted.
6. Motor (Each Vacuum Pump):
a. Horsepower: 2
b. Speed: 1750rpm.

7. Electrical Characteristics:
    a. Volts: 460.
    b. Phase(s): Three.
    c. Hertz: 60.
    d. Full-Load Amperes: 7.4.
    e. Minimum Circuit Ampacity: 15.
8. Receiver:
    a. Orientation: Vertical arrangement.
    b. Capacity: 80gal. (302 L).
    c. Pressure Rating: 100 psig (690 kPa) minimum.
    d. Interior Finish: Epoxy
    e. Drain: Automatic valve.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean vacuum equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for medical vacuum applications, according to CGA G4.1, "Cleaning Equipment for Oxygen Service."

3.2 VACUUM EQUIPMENT INSTALLATION

A. Install vacuum equipment for healthcare facilities according to ASSE 6010 and NFPA 99.
B. Equipment Mounting:
    1. Install vacuum producers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
    2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
    3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
C. Install vacuum equipment anchored to substrate.
D. Orient equipment so controls and devices are accessible for servicing.
E. Maintain manufacturer's recommended clearances for service and maintenance.
F. Install the following devices on vacuum equipment:
    1. Thermometer, Vacuum Gage, and Pressure Relief Valve: Install on each vacuum pump receiver.

2. Drain Valves: Install on receivers Discharge receiver condensate over nearest floor drain. Discharge separator oral evacuation fluids by direct connection into sanitary waste piping system.

3.3 CONNECTIONS

A. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for vacuum piping specified in Section 226213 "Vacuum Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to equipment, allow space for service and maintenance.

D. Connect vacuum piping to vacuum equipment, accessories, and specialties with shutoff valve and union or flanged connection.

3.4 IDENTIFICATION

A. Identify nonmedical laboratory vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Identify medical vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment." and with NFPA 99.

3.5 FIELD QUALITY CONTROL FOR HEALTHCARE-FACILITY MEDICAL VACUUM EQUIPMENT

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

1. Medical Vacuum Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum equipment concurrently with tests, inspections, and certification of medical vacuum piping systems.

2. Preparation: Perform medical vacuum equipment tests according to requirements in NFPA 99 for the following:

   a. System operation test.

3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030, and NFPA 99 for verification of medical vacuum equipment.

4. Replace damaged and malfunctioning controls and equipment.

5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
   a. Inspections performed.
   b. Procedures and materials used.
   c. Test methods used.
   d. Results of tests.

D. Components will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   2. Check for lubricating oil in lubricated-type equipment.
   3. Check belt drives for proper tension.
   4. Verify that vacuum producer outlet piping is clear.
   5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
   6. Check safety valves for correct settings.
   7. Check for proper seismic restraints.
   8. Drain receiver tank(s).
   9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   10. Test and adjust controls and safeties.

B. Verify that vacuum equipment is installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in electrical Sections.

D. Prepare written report documenting testing procedures and results.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain vacuum producers.

END OF SECTION 226219

SECTION 226313

GAS PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Medical Air piping, designated "medical air"
2. Oxygen piping, designated medical oxygen
3. Ball valves.
4. Check valves.
5. Emergency oxygen connections.
6. Gas safety valves.
7. Gas-service connections.
8. Patient-service outlets.
9. Gas manifolds.

B. Owner-Furnished Material:

1. Patient-head walls.

C. Related Requirements:

1. Section 226400 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. Medical gas piping systems include medical oxygen and medical air for healthcare facility patient care.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Data: Certificates, for gas manifolds from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Material Certificates: Signed by Installer, certifying that medical gas piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.

D. Brazing certificates.

E. Field quality control reports.

F. Source Quality Control Reports:

1. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For medical gas piping specialties to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Quick-Coupler Service Connections: Furnish complete noninterchangeable medical gas-pressure outlets and suction inlets.
   a. Medical Oxygen: Equal to 10 percent of quantity installed, but no fewer than 16 units.
   b. Medical Equal to 10 percent of quantity installed, but no fewer than 8 units.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Gas Piping Systems for Healthcare Facilities: In accordance with ASSE Standard #6010 and NFPA 99 for medical-gas-system installers.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel in accordance with ASSE Standard #6020 and NFPA 99 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," or AWS B2.2/B2.2M.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Medical oxygen operating at 50 to 55 psig (345 to 380 kPa) Medical air operating at 50 to 55 psig (345 to 380 kPa)

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Gas manifolds shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7

B. For life-safety components required to function after an earthquake (such as fire sprinkler systems, components that contain hazardous content, and storage racks in structures open to the public), the Component Importance Factor is 1.5. For other components, the Component Importance Factor is 1.0 unless the structure is in Seismic Use Group III and component is necessary for continued operation of facility or failure of component could impair continued operation of facility, in which case the Component Importance Factor is 1.5.

C. Comply with NFPA 55

D. Comply with NFPA 99.

2.3 PIPES, TUBES, AND FITTINGS

A. For all medical gases, all positive-pressure medical gas piping, tubing, and fittings shall have been manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.

1. Each length of tubing shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation.
2. Fittings and other components shall be delivered manufacturer sealed and labeled, and kept sealed until prepared for installation.

B. Copper Medical Gas Tube: ASTM B819, Type L, seamless, drawn temper. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue for Type L tube.

C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.5 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged in accordance with CGA G-4.1 for oxygen service.

B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gauges.

1. Steel Box with Aluminum Cover:

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1) Amico Corporation.
   2) BeaconMedaes.
   3) Chemtron
b. Description: Formed-steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gauges and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gauges may be incorporated in zone valve boxes for medical gases.
   1) Interior Finish: Factory-applied white enamel.
   2) Cover Plate: Aluminum with frangible or removable windows.
   3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, in accordance with NFPA 99.

2. Positive-pressure medical gas valves, for all medical gas types, shall be manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
   a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

C. Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Amico Corporation.
   b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
   c. BeaconMedaes.
   d. NIBCO INC.
2. Standard: MSS SP-110.
3. Description: Three-piece body, brass or bronze.
4. Pressure Rating: 300 psig (2070 kPa) minimum.
5. Ball: Full-port, chrome-plated brass.
6. Seats: PTFE or TFE.
7. Handle: Lever type with locking device.
8. Stem: Blowout proof with PTFE or TFE seal.
9. Ends: manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension.

10. Positive-pressure gas valves, for all medical gas types, shall be manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

D. Emergency Oxygen Connections: Low-pressure oxygen inlet assembly for connection to building oxygen piping systems.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Amico Corporation.
    b. BeaconMedaes.
    c. Oxequip Health Industries; a division of Allied Healthcare Products Inc.
2. Enclosure: Weatherproof hinged locking cover with caption similar to "Emergency Low-Pressure Gaseous Oxygen Inlet."
3. Inlet: Manufacturer-installed, NPS 1 or NPS 1-1/4 (DN 25 or DN 32), ASTM B819, copper tubing with NPS 1 (DN 25) minimum ball valve.
4. Safety Valve: Bronze-body pressure-relief valve set at 75 or 80 psig (520 or 550 kPa).
5. Instrumentation: Pressure gauge.
6. Positive-pressure gas valves, for all gas types, shall be manufacturer cleaned, purged, and sealed for oxygen service, in accordance with CGA G-4.1.
    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

2.6 GAS-SERVICE CONNECTIONS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amico Corporation.
2. BeaconMedaes.
3. Oxequip Health Industries; a division of Allied Healthcare Products Inc.

B. General Requirements for Medical Gas-Service Connections:
1. All positive-pressure gas-service connections, for all gas types, shall be manufacturer cleaned, purged, and sealed as for oxygen service in accordance with CGA G-4.1.
2. Suitable for specific gas pressure and suction service listed.
3. Include roughing-in assemblies, finishing assemblies, and cover plates.
4. Recessed-type units made for concealed piping unless otherwise indicated.

C. Roughing-in Assembly:
1. Steel outlet box for recessed mounting and concealed piping.

2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
3. Double seals that will prevent gas leakage.
4. ASTM B819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

D. Finishing Assembly:
1. Brass housing with primary check valve.
2. Double seals that will prevent gas leakage.
3. Cover plate with gas-service label.

E. Quick-Coupler Pressure Service Connections: Outlets for nitrous oxide, oxygen and Medical Air with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

F. Cover Plates: One piece, aluminum or stainless steel and permanent, color-coded, identifying label matching corresponding service.

2.7 GAS MANIFOLDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amico Corporation.
2. BeaconMedaes.
3. Oxequip Health Industries; a division of Allied Healthcare Products Inc.

B. Manufacturer cleaned, purged, and sealed, for all medical gas type, for oxygen service in accordance with CGA G-4.1.

C. Comply with NFPA 99 for high-pressure medical gas cylinders.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Central Control-Panel Unit:
1. Weatherproof cabinet.
2. Supply and delivery pressure gauges.
3. Electrical alarm-system connections and transformer.
4. Indicator lights or devices.
5. Manifold connection.
6. Pressure changeover switch.
7. Line-pressure regulator.
8. Shutoff valves.

9. Safety valve.

F. Manifold and Headers:

1. Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks.
2. Designed for 2000-psig (13.8-MPa) minimum inlet pressure, except nitrous oxide manifolds may be designed for 800 psig (5520 kPa).
3. Cylinder-bank headers with inlet (pigtail) connections complying with CGA V-1.
4. Individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gauge.

G. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder-bank header.

H. Mounting: Wall with mounting brackets for manifold control cabinet and headers.

I. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.

J. Medical Oxygen Manifolds: For 6 cylinders and 55-psig (380-kPa) line pressure.

K. Medical Air Manifold: For 4 cylinders and 55 psi (380-kPa)

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:

1. Clean medical gas tube and fittings, valves, gauges, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service in accordance with CGA G-4.1.
2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.
    a. Scrub to ensure complete cleaning.
    b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

A. General Location and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Comply with NFPA 99 for installation of medical gas piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

H. Install piping to permit valve servicing.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and for branch connections.

K. Install medical gas piping to medical gas-service connections specified in this Section, to medical gas-service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.

L. Install medical gas-service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

M. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.

N. Install unions in copper tubing adjacent to each valve and at final connection to each specialty and piece of equipment.

O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to gas laboratory and healthcare equipment and specialties.

B. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Arrange valves so largest valve is lowest. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on gas piping where reduced pressure is required.

F. Install emergency oxygen connection with pressure-relief valve and full-size discharge piping to outside, with check valve downstream from pressure-relief valve, and with ball valve and check valve in supply main from bulk oxygen storage tank.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

C. Threaded Joints: Apply appropriate tape to external pipe threads.

D. Brazed Joints: Join copper tube and fittings in accordance with CDA's "Copper Tube Handbook," Ch. "Brazed Joints." Do not use flux. Continuously purge joint with oil-free, dry nitrogen during brazing.

E. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

F. Soldered Joints: Apply ASTM B813, water-flushable flux to tube end. Join copper tube and fittings in accordance with ASTM B828.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Vertical Piping: MSS Type 8 or Type 42, clamps.

C. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

D. Base of Vertical Piping: MSS Type 52 spring hangers.

E. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

G. Support vertical runs of copper tubing to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 IDENTIFICATION

A. Install identifying labels and devices for specialty gas piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for healthcare medical gas piping systems in accordance with NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Medical Air: Black letters on yellow background.
2. Oxygen: White letters on green background or green letters on white background.

3.7 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL GAS

A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.
2. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

D. Tests and Inspections:

1. Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of medical air piping and medical vacuum piping systems.
2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
    a. Initial blowdown.
    b. Initial pressure test.
    c. Cross-connection test.
    d. Piping purge test.
    e. Standing pressure test for positive-pressure medical gas piping.
    f. Standing pressure test for vacuum systems.
    g. Repair leaks and retest until no leaks exist.
3. System Verification: Perform the following tests and inspections in accordance with NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:
    a. Standing pressure test.
    b. Individual-pressurization cross-connection test.
    c. Valve test.
    d. Master and area alarm tests.
    e. Piping purge test.

f. Piping particulate test.
g. Piping purity test.
h. Final tie-in test.
i. Operational pressure test.
j. Gas concentration test.
k. Air-purity test.
l. Verify correct labeling of equipment and components.
m. Verify medical gas supply sources.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed, and certify report results. Include the following:
   a. Inspections performed.
   b. Procedures, materials, and gases used.
   c. Test methods used.
   d. Results of tests.

E. Piping will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 FIELD QUALITY CONTROL FOR LABORATORY FACILITY SPECIALTY GAS

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

D. Tests and Inspections:
   1. Piping Leak Tests for Specialty Gas Piping: Test new and modified parts of existing piping. Cap and fill specialty gas piping with oil-free, dry nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa) Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   2. Repair leaks and retest until no leaks exist.
   3. Inspect specialty gas regulators for proper operation.

E. Piping will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.9 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, in accordance with "Preparation" Article.

3.10 VALVE SCHEDULE

A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

B. Zone Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gauge on one copper-tube extension.

END OF SECTION 226313

SECTION 226600

CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Single-wall pipe and fittings.
   2. Joining materials.
   3. Piping specialties.
   4. Manholes - holding tanks.
   5. High-level alarm stations.
   6. Combination high-level and leak-detection alarm stations.

1.2 DEFINITIONS

A. FPM: Vinylidene fluoride (hexafluoropropylene copolymer rubber).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For neutralization system, leak-detection systems, and pH monitoring systems and level alarms.
   1. Include plans, elevations, sections, and attachment details.
   2. Include details of leak-detection-system assemblies. Indicate required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Profile Drawings for Outdoor Underground Piping: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate underground structures and pipes. Show types, sizes, materials, and elevations of other utilities crossing system piping.

B. Coordination Drawings: Plans and other details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

C. Seismic Qualification Certificates: For tanks and tank systems, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For chemical-waste specialties to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS – NOT USED

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, fittings, and seals from dirt and damage.

1.8 FIELD CONDITIONS – NOT USED

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: **10 feet head of water for 30 minutes**.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. NFPA Compliance: Comply with NFPA 70.

D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for aboveground piping. See Section 018123 "Facility Seismic and Wind Criteria," which specifies basis-of-design seismic and wind criteria for non-structural components.

E. Seismic Performance: Piping, piping specialties, tanks, and tank systems are to withstand the effects of earthquake motions. See Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
2. Component Importance Factor: **1.0**.

2.2 SINGLE-WALL PIPE AND FITTINGS

A. PP Drainage Pipe and Fittings: ASTM F1412, extruded pipe and drainage-pattern fittings molded, with Schedule 40 dimensions and with fire-retardant additive complying with ASTM D4101; with **fusion and mechanical** joint ends.

1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
2. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.

B. CPVC Drainage Pipe and Fittings: ASTM F2618, pipe and drainage-pattern fittings.
1. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.

C. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.3 DOUBLE-WALL CONTAINMENT PIPE AND FITTINGS - NOT USED

2.4 FIELD-FABRICATION CONTAINMENT PIPING - NOT USED

2.5 JOINING MATERIALS

A. Couplings: Assemblies with combinations of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

D. Solvent Cement for Joining CPVC Piping: ASTM F493. Include primer in accordance with ASTM F656.

2.6 PIPING SPECIALTIES

A. Corrosion-Resistant Traps:
1. Type: P-trap or drum trap.
2. Size: NPS 1-1/2 or NPS 2, as required to match connected piping.
3. High-Silicon Iron: ASTM A861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
4. PP: ASTM D4101, with mechanical-joint pipe connections.

B. Plastic Floor Drains FD-2:
1. Manufacturer:
a. Zurn
b. J.R. Smith
c. Oatey
2. Source Limitations: Obtain floor drains from single source from single manufacturer.
3. Body: With 4- to 6-inch top diameter, with flashing flange and weep holes.
4. Inlet: Bottom, to match connecting pipe, with outlet as indicated.

2.7 NEUTRALIZATION TANKS - NOT USED

2.8 NEUTRALIZATION SYSTEMS - NOT USED

2.9 MANHOLES - HOLDING TANKS

A. Manufacturers:
   1. Jensen Precast
   2. Oldcastle
   3. Vaugh Concrete Products

B. Source Limitations: Obtain holding tanks from single source from single manufacturer.

C. Description: Fabricated from pre-cast concrete components. Include bottom, sidewalls, and top sections; corrosion-resistant, tanks frame and cover; fusion or other watertight joints; and design to prohibit flotation.

D. Construction: **Single wall**.

E. Connections: Inlets and outlet matching or suitable for piping.

F. Top: Include 24-inch (610-mm) nominal-diameter frame and cover.

2.10 LEAK-DETECTION SYSTEMS – NOT USED

2.11 pH MONITORING SYSTEMS – NOT USED

2.12 HIGH-LEVEL ALARM STATIONS

A. High-Level Alarm Station:
   1. Description: High-level alarm stations for tanks.
   2. Alarm Panel:
      a. Enclosure: UL-listed.
      b. 120 V ac, 60 Hz.
      c. Integral Alarm Horn: 100 at 10 feet.
      d. Integral red-light beacon that remains active until alarm state is resolved.
      e. Horn silence switch.
      f. Alarm test switch.
   3. High-Level Alarm Sensor:
      a. Polypropylene NO float sensor with solid polypropylene exposed float.
      b. Maximum Operating Temperature:**194 deg F**.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 CONCRETE BASES – NOT USED

3.3 INSTALLATION OF PIPING

A. Chemical-Waste Sewerage Outside the Building:

1. Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground chemical-waste sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's written instructions for using lubricants, cements, and other installation requirements.
3. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
4. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
5. Install drainage piping pitched down in direction of flow, at minimum slope of **2** percent unless otherwise indicated.
6. Install drainage piping with **36-inch (900-mm)** minimum cover.
7. Install CPVC drainage piping in accordance with ASTM D2321 and ASTM F1668.
8. Install field-fabrication containment piping over [**new and**] existing carrier piping. Use containment piping manufacturer's fastening system.
9. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain a swab or drag inside piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

B. Chemical-Waste Piping Inside the Building:

1. Install piping adjacent to equipment, accessories, and specialties, to allow space for service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
5. Install piping at indicated slopes.
6. Install piping free of sags and bends.

7. Install fittings for changes in direction and branch connections.
8. Verify final equipment locations for roughing-in.

3.4 INSTALLATION OF PIPING SPECIALTY

A. Embed floor drains in 4-inch minimum depth of concrete around bottom and sides. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete.
B. Fasten grates to drains if indicated.
C. Set floor drains with tops flush with pavement surface.
D. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
   1. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches) deep. Set with tops flush surrounding grade. Set cleanout plugs in concrete pavement, with tops flush with pavement surface. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for formwork, reinforcement, and concrete requirements.
E. Install backwater valves in horizontal position. Include riser to cleanout at grade.

3.5 JOINT CONSTRUCTION

A. Chemical-Waste Sewerage Outside the Building:
   1. Plastic-Piping Fusion Joints: Make plastic drainage-piping joints in accordance with ASTM F1290.
   2. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.
B. Chemical-Waste Piping Inside the Building:
   1. Plastic-Piping Fusion Joints: Make plastic drainage-piping joints in accordance with ASTM F1290.
   2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

3.6 INSTALLATION OF HANGER AND SUPPORT – NOT USED

3.7 INSTALLATION OF NEUTRALIZATION TANK – NOT USED

3.8 INSTALLATION OF NEUTRALIZATION SYSTEM – NOT USED

3.9 INSTALLATION OF MANHOLE - HOLDING TANK

A. General: Install tanks, complete with appurtenances and accessories indicated. Comply with requirements in Section 333115 "Site Sanitary Sewerage Piping."
B. Set tops of tank frames and covers flush with finished surface where tanks occur in pavements. Set tops flush to finished surface elsewhere unless otherwise indicated.

3.10 INSTALLATION OF LEAK-DETECTION SYSTEM – NOT USED

3.11 CONCRETE PLACEMENT

A. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete supports.

B. Place cast-in-place concrete in accordance with ACI 318/318R.

3.12 PIPING CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

3.13 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.

1. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.14 ADJUSTING

A. Adjust neutralization-system set points.

B. Adjust leak-detection-system control and device settings.

3.15 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Clean piping by flushing with potable water.

3.16 STARTUP SERVICE – NOT USED

3.17 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place and again at completion of Project.

1. Defects requiring correction include the following:
   a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
   b. Crushed, broken, cracked, or otherwise damaged piping.
   c. Hydrostatic Tests for Drainage Piping:
      1) Allowable leakage is a maximum of **1 gal./inch of nominal pipe size per mile** of pipe during 24-hour period.
      2) Close openings in system and fill with water.
      3) Purge air and refill with water.
      4) Disconnect water supply.
      5) Test and inspect joints for leaks.

d. Air Tests for Drainage Piping: Comply with UNI-B-6.

2. Leaks and loss in test pressure constitute defects that must be repaired.
3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Testing Agency: **Engage** a qualified testing agency to perform tests and inspections.

D. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

F. Tests and Inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect tank assembly - and their installation, including piping and electrical connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.18 DEMONSTRATION – NOT USED

3.19 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.

B. Single-Wall, Chemical-Waste Sewerage Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 4 (DN 40 to DN 100) PP: Drainage pipe and fittings and fusion joints.
2. NPS 1-1/2 to NPS 4 (DN 40 to DN 100) CPVC: Drainage pipe and fittings and solvent-cemented joints.

C. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) PP: Drainage piping and fusion joints.
2. NPS 1-1/2 to NPS 6 (DN 40 to DN 150) PVDF: Drainage piping and fusion joints.

END OF SECTION 226600

SECTION 230500

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Motors.
2. Alignment guides and anchors.
3. Sleeves without waterstop.
4. Sleeves with waterstop.
5. Stack-sleeve fittings.
6. Sleeve-seal systems.
7. Grout.
8. Silicone sealants.
9. Escutcheons.
10. Test plugs.
11. Test-plug kits.
12. Flowmeters.

B. Related Requirements:

1. Section 230923.13 "Energy Meters" for thermal-energy meters connecting with the DDC system.
2. Section 230923.14 "Flow Instruments" for primary flow instruments connecting with the DDC system.

1.2 DEFINITIONS – NOT USED

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product, excluding motors which are included in Part 1 of HVAC equipment Sections.
   a. Include construction details, material descriptions, and dimensions of individual components, and finishes.
   b. Include operating characteristics and furnished accessories.

B. Delegated Design Submittals: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.

2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter.
B. Welding certificates.
C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of meter and gauge to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M and AWS D1.4/D1.4M.

1.7 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 MOTORS

A. Motor Requirements, General:
1. Content includes motors for use on alternating-current power systems of up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
2. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
3. Comply with NEMA MG 1 unless otherwise indicated.

B. Motor Characteristics:
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 ft. (1000 m) above sea level.

2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Premium Efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
   a. For motors with 2:1 speed ratio, consequent pole, single winding.
   b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors, Two Winding: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:
    a. Motors 15 Hp and Larger: NEMA starting Code F or Code G.
    b. Motors Smaller Than 15 Hp: Manufacturer's standard starting characteristic.
11. Enclosure Material: Cast iron for motor frame sizes 324T; rolled steel for motor frame sizes smaller than 324T.

D. Additional Requirements for Polyphase Motors:

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time-rise pulses produced by pulse-width-modulated inverters.
   b. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

E. Single-Phase Motors:
1. Motors larger than 1/20 hp must be one of the following, to suit starting torque and requirements of specific motor application:
a. Permanent-split capacitor.
b. Split phase.
c. Capacitor start, inductor run.
d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 hp and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device will automatically reset when motor temperature returns to normal range.

F. Electronically Commutated Motors:
1. Microprocessor-Based Electronic Control Module: Converts 120 V single-phase AC power to three-phase DC power to operate the brushless DC motor.
2. Three-phase power motor module with permanent magnet rotor.
3. Circuit board or digital speed controller/LED display.
4. Building Automation System Interface: Via AC voltage signal.

2.2 EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING – NOT USED

2.3 SLEEVES AND SLEEVE SEALS

A. Sleeves without Waterstop:
1. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
2. Steel Sheet Sleeves: ASTM A653/A653M, 24 gauge (0.6 mm) minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.
3. PVC Pipe Sleeves: ASTM D1785, Schedule 40.
4. Molded-PVC Sleeves: With nailing flange.
5. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange.

B. Sleeves with Waterstop:
1. Description: Manufactured galvanized-steel, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.

C. Stack-Sleeve Fittings:
1. Description: Manufactured, Dura-coated cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
a. Underdeck Clamp: Clamping ring with setscrews.

D. Sleeve-Seal Systems:
1. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
a. Hydrostatic seal: 20 psig (137 kPa) minimum.
b. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
c. Pressure Plates: Carbon steel.
d. Connecting Bolts and Nuts: Carbon steel, with zinc coating. ASTM B633 of length required to secure pressure plates to sealing elements.

E. Grout:
1. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
3. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

F. Silicone Sealants:
1. Silicone Sealant, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant.
a. Standard: ASTM C920, Type S, Grade NS, Class 25, Use NT.
2. Silicone Foam Sealant: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

2.4 ESCUTCHEONS

A. Escutcheon Types:
1. One-Piece, Steel Type: With **polished, chrome-plated** finish and setscrew fastener.
2. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

B. Floor Plates:
1. Split Floor Plates: Steel with concealed hinge.

2.5 METERS AND GAUGES FOR HVAC PIPING

A. Test Plugs:

1. Source Limitations: Provide test plugs from single manufacturer.
2. Description: Test-station fitting made for insertion in piping tee fitting.
3. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
4. Thread Size: NPS 1/4 (DN 8 or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.
5. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
6. Core Inserts: EPDM self-sealing rubber.

B. Test-Plug Kits:

1. Source Limitations: Provide test-plug kits from single manufacturer.
2. Furnish **one** test-plug kit(s) containing **one** thermometer, one pressure gauge and adapter, and carrying case. Thermometer sensing elements, pressure gauge, and adapter probes are to be of diameter to fit test plugs and of length to project into piping.
3. Low-Range Thermometer: Small, bimetallic insertion type with **1- to 2-inch- (25- to 50-mm)** diameter dial and tapered-end sensing element. Dial range is to be at least **25 to 125 deg F (minus 4 to plus 52 deg C)**.
4. Pressure Gauge: Small, Bourdon-tube insertion type with **2- to 3-inch- (50- to 75-mm-)** diameter dial and probe. Dial range shall be at least **0 to 200 psig (0 to 1380 kPa)**.
5. Carrying Case: Metal or plastic, with formed instrument padding.

C. Flowmeters:

1. Performance Requirements: Manufacturer is to certify that each flowmeter complies with specified performance requirements and characteristics.
2. Flowmeters - Turbine:
   a. Source Limitations: Provide turbine flowmeters from single manufacturer.
   b. Description: Flowmeter with sensor and indicator.
   c. Flow Range: Sensor and indicator are to cover operating range of equipment or system served.
   d. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in gpm (Lps).
      1) Design: Device or pipe fitting with inline turbine and integral direct-reading scale for **water**.
      2) Construction: Bronze or stainless steel body, with plastic turbine or impeller.

3) Fitting for mounting probe in pipe, with **threaded** connection for attachment to pipe. Provide way to permit removal of probe for service.

4) Minimum Pressure Rating: **150 psig (1035 kPa)**.

5) Minimum Temperature Rating: 15°F (-9.4°C).

e. Indicator: Handheld meter; either an integral part of sensor or a separate meter.

f. Accuracy: Plus or minus **1-1/2** percent.

g. Display: Shows rate of flow**, with register to indicate total volume in gallons (liters)**.

h. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES - GENERAL

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide **1-inch (25-mm)** annular clear space between piping and concrete slabs and walls.

1. Sleeves are not required for core-drilled holes.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.

2. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas **2 inches (50 mm)** above finished floor level.

3. Using **silicone sealant**, seal space outside of sleeves in floors/slabs/walls without sleeve-seal system. Select to maintain fire resistance of floor/slab/wall.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants that joint sealant manufacturer's literature indicates is appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with

requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 INSTALLATION OF SLEEVES WITH WATERSTOP

A. Install sleeve with waterstop as new walls and slabs are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange centered across width of concrete slab or wall.

C. Secure nailing flanges to wooden concrete forms.

D. Using **silicone sealant**, seal space around outside of sleeves.

3.3 INSTALLATION OF STACK-SLEEVE FITTINGS

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 3 inches (76 mm) above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.

B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.4 INSTALLATION OF SLEEVE-SEAL SYSTEMS

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building, and passing through exterior walls.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.5 INSTALLATION OF ESCUTCHEONS

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

3.6 INSTALLATION OF METERS AND GAUGES

A. Install test plugs in piping tees.

B. Install flow indicators in piping systems in accessible positions for easy viewing.

C. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

D. Install flowmeter elements in accessible positions in piping systems.

E. Install all flowmeter elements, with at least 4 diameters minimum straight lengths of pipe, upstream and downstream from element.

F. Install permanent indicators on walls or brackets in accessible and readable positions.

G. Install connection fittings in accessible locations for attachment to portable indicators.

3.7 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

3.8 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gauges to proper angle for best visibility.

3.9 FIELD QUALITY CONTROL

A. Sleeves and Sleeve Seals:

1. Perform the following tests and inspections:

a. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

b. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

2. Prepare test and inspection reports.

B. Escutcheons:

1. Using new materials, replace broken and damaged escutcheons and floor plates.

3.10 SLEEVES APPLICATION

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Sleeves with waterstops.

1) Select sleeve size to allow for **1-inch (25-mm)** annular clear space between piping and sleeve for installing sleeve-seal system.

2. Concrete Slabs-on-Grade:

a. Sleeves with waterstops.

1) Select sleeve size to allow for **1-inch (25-mm)**] annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs above Grade:

a. **Sleeves with waterstops**.

4. Interior Walls and Partitions:

a. Sleeves without waterstops.

3.11 ESCUTCHEONS APPLICATION

A. Escutcheons for New Piping and Relocated Existing Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Chrome-Plated Piping: One piece, **steel** with polished, chrome-plated finish.
3. Insulated Piping:

a. One piece, steel with **polished, chrome-plated** finish.

4. Bare Piping at Wall and Floor Penetrations in Finished Spaces:

a. One piece, steel with **polished, chrome-plated** finish.

5. Bare Piping at Ceiling Penetrations in Finished Spaces:

a. One piece, steel with **polished, chrome-plated** finish.

6. Bare Piping in Unfinished Service Spaces:

a. One piece, steel with polished, chrome-plated finish.

7. Bare Piping in Equipment Rooms:

a. One piece, steel with polished, chrome-plated finish.

B. Install floor plates for piping penetrations of equipment-room floors.

C. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: Split floor plate.
2. Existing Piping to Remain: Split floor plate.

3.12 FLOWMETER APPLICATION

A. Flowmeters for Chilled-Water Piping: **Turbine** type.

END OF SECTION 230500

SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS`

A. Duty: Continuous duty at ambient temperature of 100 deg F and at altitude of 0 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:

1. Motors 10 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 10 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers:

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION - NOT USED

END OF SECTION 230513

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SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fastener systems.
2. Equipment supports.

B. Related Requirements:

1. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
2. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Pipe stands.
2. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel or stainless steel.

2.3 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or stainless-steel.
2. Outdoor Applications: Stainless steel.

2.4 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.5 MATERIALS

A. Aluminum: ASTM B 221 (ASTM B 221M).

B. Carbon Steel: ASTM A 1011/A 1011M.

C. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; galvanized.

D. Stainless Steel: ASTM A 240/A 240M.

E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.

PART 3 - EXECUTION

3.1 APPLICATION

A. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

A. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

B. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

C. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

D. Install lateral bracing with pipe hangers and supports to prevent swaying.

E. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

F. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

H. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of **steel** I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

I. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

J. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

K. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

L. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

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SECTION 230546

COATINGS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. General provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes application of coating systems on internal HVAC components and external equipment surfaces, including the following systems:

1. Bake-cured corrosion-resistant coating systems.
2. Air-dried corrosion-resistant coating systems.

1.3 DEFINITIONS

A. Salt Water Acetic Acid Test (SWAAT): A salt fog-spray test of corrosion resistance performed in accordance with ASTM G85, Annex 3.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product. Include Safety Data Sheets, preparation requirements, and application instructions.

1.5 INFORMATIONAL SUBMITTALS

A. Source Quality-Control Reports:

1. Certification of coating material testing.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Coatings: 1 container of each material and color applied, including base coat and top coat products.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in clean, dry, well-ventilated areas with ambient temperatures continuously maintained between 50 and 75 deg F (10 and 24 deg C).

1. Keep containers out of direct sunlight; avoid excessive heat and keep from freezing.
2. Maintain containers in clean condition, free of foreign materials and residue.
3. Remove rags and waste from storage areas daily.

1.8 CONDITIONS FOR COATING APPLICATION

A. Comply with manufacturer's recommendations regarding required temperature and humidity ranges during coating application.

PART 2 - PRODUCTS

2.1 CORROSION-RESISTANT COATING SYSTEMS, GENERAL

A. Material Compatibility:

1. Provide materials for application within each coating system that are compatible with one another and with metal substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coating material in coating system, submit compatibility certification from manufacturer of each coating product that products are compatible with substrate base material and with substrate-coating products applied as earlier coats.
3. Products shall be of same manufacturer for each coat in a coating system.

B. Colors: Manufacturer's standard.

2.2 BAKE-CURED CORROSION-RESISTANT COATING SYSTEMS

A. Base Coat Performance Requirements:

1. Corrosion Resistance: ASTM B117: 1500.
2. Cross-Hatch Adhesion: ASTM D3359: 5B.
3. SWAAT: ASTM G85: 1000.
4. Cyclic Weathering: ISO 12944-9, 4200 hours.
5. Mandrel Flexibility: ASTM D522/D522M: 1/4 inch (6 mm) without cracking or delamination of film after full cure.
6. Adhesion - Elcometer: ASTM D4541: 1100 psi (7.6 MPa).
7. Impact: ASTM D2794.
   a. Direct Hit: 70 lb.-in. (7.9 N-m).
   b. Reverse Hit: 20 lb.-in. (2.2 N-m).
8. pH Range, 14-Day Liquid Spot Test: 2.4 to 12.6.
9. Dry Heat Resistance: ASTM D2485: 320 deg F (160 deg C) maximum.
10. Dry Film Thickness: 0.5 to 1.2 mils (0.013 to 0.030 mm).
11. Heat-Transfer Reduction: 1 percent maximum.
12. Hardness: ASTM D3363 Pencil Test: 2B-HB.

B. Bake-Cured Top Coat Performance Requirements: Provide product with UV shielding properties, color stability, and maintenance of manufacturer's standard sheen, after exposure to outdoor conditions.

2.3 AIR-DRIED CORROSION-RESISTANT COATING SYSTEMS

A. Performance Requirements:

1. Corrosion Resistance: ASTM B117: 1500 hours.
2. Cross-Hatch Adhesion: ASTM D3359: 5B.

3. Cyclic Weathering: ISO 12944-9, Offshore Standard: 4200 hours.
4. Mandrel Flexibility: ASTM D522/D522M: 1/2 inch (13 mm) without cracking or delamination of film after full cure.
5. Impact: ASTM D2794.
   a. Direct Hit: 100 in-lb (11.3 N-m).
6. Dry Heat Resistance: ASTM D2485: 356 deg F (180 deg C) maximum.
7. Dry Film Thickness: 2 to 3 mils (0.050 to 0.075 mm).
8. Heat-Transfer Reduction: 1 percent maximum.
9. Hardness: ASTM D3363 Pencil Test: 2B-HB.

B. Base Coat Performance Requirements:
1. Corrosion Resistance: ASTM B117: 1500 hours.
2. SWAAT: ASTM G85: 1000 hours.
3. Cyclic Weathering: ISO 12944-9: 4200 hours.
4. Cross-Hatch Adhesion: ASTM D3359: 5B.
5. Mandrel Flexibility: ASTM D522/D522M: 1/8 inch (3 mm) without cracking or delamination of film after full cure.
6. Adhesion - Elcometer: ASTM D4541: 1,100 psi (7.6 MPa).
7. Impact: ASTM D2794.
   a. Direct Hit: 100 lb.-in. (11.3 N-m).
8. Dry Heat Resistance: ASTM D2485: 250 deg F (121 deg C) maximum.
9. Dry Film Thickness: 0.5 to 1.2 mils (0.013 to 0.030 mm).
10. Heat-Transfer Reduction: 1 percent.
11. Hardness: ASTM D3363 Pencil Test: 2B-HB.

C. Air-Dried Top Coat Performance Requirements: Provide product with UV shielding properties, color stability, and maintenance of manufacturer's standard sheen, after exposure to outdoor conditions.

2.4 SOURCE QUALITY CONTROL

A. Certification of Coating Material Testing: Submit manufacturer's test report of corrosion-resistance performance testing, as performed by a nationally recognized testing laboratory.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with coating manufacturer's requirements and other conditions affecting performance of the Work.

B. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

C. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

A. Comply with manufacturer's written instructions applicable to substrates and coating systems indicated.

1. Thinning: Thin coating material with manufacturer's recommended thinning products when recommended or permitted by coating system manufacturer.

B. Comply with coating system manufacturer's recommendations to clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

3.3 APPLICATION

A. Verify with coating manufacturer whether coatings required must be applied and cured in factory-certified application shop.

B. Apply coating systems with equipment designed to deposit coating of specified uniform thickness over HVAC components, in complex, three-dimensional geometries.

1. Apply coatings with manufacturer-recommended tools and techniques suited for specified coating system and each coated HVAC component.

2. Do not apply coatings over labels or equipment name, identification, performance rating, or nomenclature plates.

C. Perform inspection and coating system manufacturer's recommended tests to verify coating integrity and thickness. Where coating was damaged by testing, repair damage in accordance with coating system manufacturer's written recommendations.

END OF SECTION 230546

SECTION 230548

VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric hangers.
3. Spring hangers.
4. Snubbers.
5. Restraint channel bracings.
6. Restraint cables.
7. Seismic-restraint accessories.
8. Mechanical anchor bolts.

B. Related Requirements:

1. Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" " for devices for plumbing equipment and systems.

1.3 DEFINITIONS

A. IBC: International Building Code.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
    b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic and wind forces required to select vibration isolators and seismic and wind restraints and for designing vibration isolation bases.
   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic- and Wind-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
   d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 150 miles per hour.
2. Building Classification Category: II.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Design Spectral Response Acceleration at Short Periods (0.2 Second): 1.50g.
3. Design Spectral Response Acceleration at 1.0-Second Period: 0.60g.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Smooth pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.
7. Sandwich-Core Material: elastomeric.
   a. Surface Pattern: Smooth pattern.
   b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.4 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.5 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

2.6 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.7 RESTRAINT CABLES

A. Restraint Cables: ASTM A 603 galvanized or ASTM A 492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.8 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or reinforcing steel angle clamped to hanger rod.
B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.9 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.

3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Install cables so they do not bend across edges of adjacent equipment or building structure.

F. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

G. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

H. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

I. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

J. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.

4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.

5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment.

3.5 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Test and adjust restrained-air-spring isolator controls and safeties.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

END OF SECTION 230548

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Duct labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.
3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater

viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Blue.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch (13 mm) for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.4 STENCILS

A. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, alkyd enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel. Paint may be in pressurized spray-can form.

B. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Fiberboard or metal.
3. Stencil Paint: Exterior, gloss, alkyd enamel. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel. Paint may be in pressurized spray-can form.

2.5 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.

C. Pipe Label Color Schedule:

1. Heating Water Piping: Black letters on a safety-orange background.

3.5 DUCT LABEL INSTALLATION

A. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 WARNING-TAG INSTALLATION

A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 230553

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SECTION 230593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
    a. Constant-volume air systems.
2. Testing, Adjusting, and Balancing Equipment:
    a. Motors.
    b. Heat-transfer coils.
3. Testing, adjusting, and balancing existing systems and equipment.
4. Sound tests.
5. Duct leakage tests.
6. Control system verification.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. BAS: Building automation systems.

C. NEBB: National Environmental Balancing Bureau.

D. TAB: Testing, adjusting, and balancing.

E. TABB: Testing, Adjusting, and Balancing Bureau.

F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.

1. Minimum Agenda Items:
    a. The Contract Documents examination report.
    b. The TAB plan.
    c. Needs for coordination and cooperation of trades and subcontractors.
    d. Proposed procedures for documentation and communication flow.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Examination Report: Submit a summary report of the examination review required in "Examination" Article.

E. Certified TAB reports.

F. Sample report forms.

G. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC, NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC, NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by AABC, NEBB or TABB as a TAB technician.

B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.7 FIELD CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data including fan curves.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

I. Examine operating safety interlocks and controls on HVAC equipment.

J. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete.
c. Clean filters are installed.
d. Fans are operating, free of vibration, and rotating in correct direction.
e. Automatic temperature-control systems are operational.
f. Ceilings are installed.
g. Windows and doors are installed.
h. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
   c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
2. Measure fan static pressures as follows:
   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report artificial loading of filters at the time static pressures are measured.
3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
   1. Measure airflow of submain and branch ducts.
   2. Adjust submain and branch duct volume dampers for specified airflow.
   3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.
   1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
   2. Measure inlets and outlets airflow.
   3. Adjust each inlet and outlet for specified airflow.
   4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.
   1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
   2. Re-measure and confirm that total airflow is within design.
   3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
   4. Mark all final settings.
   5. Measure and record all operating data.
   6. Record final fan-performance data.

3.6 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer's name, model number, and serial number.
   2. Motor horsepower rating.
   3. Motor rpm.
   4. Phase and hertz.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter size and thermal-protection-element rating.
   8. Service factor and frame size.

B. PROCEDURES FOR HEAT-TRANSFER COILS

C. Measure, adjust, and record the following data for each electric heating coil:
   1. Nameplate data.
   2. Airflow.
   3. Entering- and leaving-air temperature at full load.
   4. Voltage and amperage input of each phase at full load.
   5. Calculated kilowatt at full load.

6. Fuse or circuit-breaker rating for overload protection.

3.7 SOUND TESTS

A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 5 locations as designated by the Architect.

B. Instrumentation:

1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels and measuring the equivalent continuous sound pressure level (LEQ).
3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 31.5 Hz to 4000 Hz (RC) with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 31.5 Hz to 4000 Hz (RC) with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
   a. Location.
   b. System tested.
   c. dBA reading.
   d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on RC worksheet with equipment on and off.

3.8 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.9 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.10 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus 10 percent or minus 0 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems

found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   2. Include a list of instruments used for procedures, along with proof of calibration.
   3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:
   1. Fan curves.
   2. Manufacturers' test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:
   1. Title page.
   2. Name and address of the TAB specialist.
   3. Project name.
   4. Project location.
   5. Architect's name and address.
   6. Engineer's name and address.
   7. Contractor's name and address.
   8. Report date.
   9. Signature of TAB supervisor who certifies the report.
   10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
   11. Summary of contents including the following:
      a. Indicated versus final performance.
      b. Notable characteristics of systems.
      c. Description of system operation sequence if it varies from the Contract Documents.
   12. Nomenclature sheets for each item of equipment.
   13. Data for terminal units, including manufacturer's name, type, size, and fittings.
   14. Notes to explain why certain final data in the body of reports vary from indicated values.

15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Settings for supply-air, static-pressure controller.
    g. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Duct, outlet, and inlet sizes.
3. Terminal units.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches, and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches.
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.
2. Motor Data:
    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
    a. Total airflow rate in cfm.

b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

F. Apparatus-Coil Test Reports:
1. Coil Data:
a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.

G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.

e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches.

2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

I. Air-Terminal-Device Reports:

1. Unit Data:
a. System and air-handling unit identification.

b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Air velocity in fpm.
c. Preliminary airflow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final airflow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
1. Unit Data:
a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):
a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

K. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.

d. Dates of use.

e. Dates of calibration.

3.13 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Architect.

B. Architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

3. If the second verification also fails, Architect may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713

DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, concealed return located in unconditioned space.

B. Related Sections:

1. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

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

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having

jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," and "Indoor Duct and Plenum Insulation Schedule," articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket or

Type III with factory-applied FSP jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. As manufactured by Knauf, Certainteed, or Owens-Corning.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. As manufactured by Knauf, Certainteed, or Owens-Corning.

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. As manufactured by Knauf, Certainteed, or Owens-Corning.

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
2. Service Temperature Range: 0 to 180 deg F.
3. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
4. Color: White.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
2. Service Temperature Range: 0 to plus 180 deg F.
3. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

2.8 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

2.9 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

2.10 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 11.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Width: 3 inches.
   2. Thickness: 6.5 mils.
   3. Adhesion: 90 ounces force/inch in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches.
   2. Thickness: 6 mils.
   3. Adhesion: 64 ounces force/inch in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches.
   2. Thickness: 3.7 mils.
   3. Adhesion: 100 ounces force/inch in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:
   1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 3/4 inch wide with wing seal or closed seal.

2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
    a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.

D. Wire: 0.080-inch nickel-copper alloy

2.12 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation

face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.

2. Indoor, concealed return located in unconditioned space.

B. Items Not Insulated:

1. Fibrous-glass ducts.

2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

3. Factory-insulated flexible ducts.

4. Factory-insulated plenums and casings.

5. Flexible connectors.

6. Vibration-control devices.

7. Factory-insulated access panels and doors.

3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
   2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

C. Concealed, round and flat-oval, exhaust-air duct insulation shall be uninsulated:

D. Concealed, rectangular, supply-air duct insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
   2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

E. Concealed, rectangular, return-air duct insulation shall be one of the following:
   1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
   2. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

F. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be uninsulated:

G. Concealed, supply-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

H. Concealed, return-air plenum insulation shall be the following:
   1. Mineral-Fiber Board: 1-1/2 inches thick and 2-lb/cu. ft. nominal density.

END OF SECTION 230713

SECTION 230923

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:

1. Section 230923.12 “Control Dampers”
2. Section 230923.14 “Flow Instruments”
3. Section 230923.22 "Position Instruments"
4. Section 230923.23 “Pressure Instruments”
5. Section 230923.27 “Temperature Instruments”
6. Section 260526 “Grounding and Bonding for Electrical Systems”
7. Section 260533 “Raceways and Boxes for Electrical Systems”

1.3 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.

5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. E/P: Voltage to pneumatic.

L. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

M. HLC: Heavy load conditions.

N. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

O. I/P: Current to pneumatic.

P. LAN: Local area network.

Q. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

R. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

S. MTBF: Mean time between failures.

T. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

U. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

V. PDA: Personal digital assistant.

W. Peer to Peer: Networking architecture that treats all network stations as equal partners.

X. POT: Portable operator's terminal.

Y. PUE: Performance usage effectiveness.

Z. RAM: Random access memory.

AA. RF: Radio frequency.

BB. Router: Device connecting two or more networks at network layer.

CC. Server: Computer used to maintain system configuration, historical and programming database.

DD. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

EE. UPS: Uninterruptible power supply.

FF. USB: Universal Serial Bus.

GG. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

HH. VAV: Variable air volume.

II. WLED: White light emitting diode.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.

2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
    a. Gateways.
    b. Routers.
    c. DDC controllers.
    d. Enclosures.
    e. Electrical power devices.
    f. UPS units.
    g. Accessories.
    h. Instruments.
    i. Control dampers and actuators.
    j. Control valves and actuators.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

C. Shop Drawings:
1. General Requirements:
    a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
    b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
    c. Prepare Drawings using CAD.
    d. Drawings Size: 11X17
2. Include plans, elevations, sections, and mounting details where applicable.

3. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Schematic drawings for each controlled HVAC system indicating the following:
   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.
5. Control panel drawings indicating the following:
   a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
   b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
   c. Front, rear, and side elevations and nameplate legend.
   d. Unique drawing for each panel.
6. DDC system network riser diagram indicating the following:
   a. Each device connected to network with unique identification for each.
   b. Interconnection of each different network in DDC system.
   c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or fiber-optic cable type. Indicate raceway type and size for each.
   d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
7. DDC system electrical power riser diagram indicating the following:

a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
d. Power wiring type and size, race type, and size for each.

8. Monitoring and control signal diagrams indicating the following:
   a. Control signal cable and wiring between controllers and I/O.
   b. Point-to-point schematic wiring diagrams for each product.
   c. Control signal tubing to sensors, switches and transmitters.
   d. Process signal tubing to sensors, switches and transmitters.
9. Color graphics indicating the following:
   a. Itemized list of color graphic displays to be provided.
   b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
   c. Intended operator access between related hierarchical display screens.

D. System Description:
1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
   a. Loss of power.
   b. Loss of network communication signal.
   c. Loss of controller signals to inputs and outpoints.
   d. Operator workstation failure.
   e. Server failure.
   f. Gateway failure.
   g. Network failure
   h. Controller failure.
   i. Instrument failure.

j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

E. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.
   a. Flow at Project design and minimum flow conditions.
   b. Face velocity at Project design and minimum airflow conditions.
   c. Pressure drop across damper at Project design and minimum airflow conditions.
   d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
   e. Maximum close-off pressure.
   f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.
3. Schedule and design calculations for control valves and actuators.
   a. Flow at Project design and minimum flow conditions.
   b. Pressure-differential drop across valve at Project design flow condition.
   c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
   d. Design and minimum control valve coefficient with corresponding valve position.
   e. Maximum close-off pressure.
   f. Leakage flow at maximum system pressure differential.
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.
   i. Actuator signal to control damper (on, close or modulate).
   j. Actuator position on loss of power.
   k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.
   a. Instrument flow range.
   b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
   c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
   d. Pressure-differential loss across instrument at Project design flow conditions.
   e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:
   1. Systems Provider Qualification Data:
      a. Resume of project manager assigned to Project.
      b. Resumes of application engineering staff assigned to Project.
      c. Resumes of installation and programming technicians assigned to Project.
      d. Resumes of service technicians assigned to Project.
      e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
      f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
      g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
      h. Owner contact information for past project including name, phone number, and e-mail address.
      i. Contractor contact information for past project including name, phone number, and e-mail address.
      j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.
   2. Manufacturer's qualification data.
   3. Testing agency's qualifications data.

B. Product Certificates:
   1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.

C. Product Test Reports: For each product that requires testing to be performed by manufacturer.

D. Preconstruction Test Reports: For each separate test performed.

E. Source quality-control reports.

F. Sample Warranty: For manufacturer's warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.

b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.

c. As-built versions of submittal Product Data.

d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.

e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.

f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.

2) Perform preventive maintenance and calibration.

3) Debug hardware problems.

4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.

i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.

j. List of recommended spare parts with part numbers and suppliers.

k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.

l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

m. Licenses, guarantees, and warranty documents.

n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

o. Owner training materials.

1.8 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. Each person assigned to Project shall have demonstrated past experience.
3. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
4. Service and maintenance staff assigned to support Project during warranty period.
5. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
6. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
   a. Install updates only after receiving Owner's written authorization.
3. Warranty service shall occur during normal business hours and commence within 2 hours of Owner's warranty service request.
4. Warranty Period: 1 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Siemens Building Technologies, Inc.
2. Trane Company
3. Johnson Controls International

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software

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

2.3 WEB ACCESS

A. DDC system shall be Web compatible.

1. Web-Compatible Access to DDC System:
   a. Operator workstation and or server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
   b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
   c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:
   a. DDC system shall manage HVAC systems.
   b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
   c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
   d. DDC system shall operate while unattended by an operator and through operator interaction.
   e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 50 or less.

C. DDC System Speed:
   1. Response Time of Connected I/O:
      a. AI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      b. BI point values connected to DDC system shall be updated at least every five seconds for use by DDC controllers. Points used globally shall also comply with this requirement.
      c. AO points connected to DDC system shall begin to respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
      d. BO point values connected to DDC system shall respond to controller output commands within two second(s). Global commands shall also comply with this requirement.
   2. Display of Connected I/O:
      a. Analog point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
      b. Binary point COV connected to DDC system shall be updated and displayed at least every 10 seconds for use by operator.
      c. Alarms of analog and digital points connected to DDC system shall be displayed within 30 seconds of activation or change of state.
      d. Graphic display refresh shall update within eight seconds.
      e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

D. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

E. DDC System Data Storage:

1. Expand existing serve storage capacity as required to additional points.

F. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:
   a. Thermal: Within 3 percent of reading.
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.
2. Flow:
   a. Air: Within 5 percent of design flow rate.
   b. Air (Terminal Units): Within 5 percent of design flow rate.
3. Gas:
   a. Carbon Dioxide: Within 50 ppm.
   b. Carbon Monoxide: Within 5 percent of reading.
4. Moisture (Relative Humidity):
   a. Air: Within 5 percent RH.
   b. Space: Within 5 percent RH.
   c. Outdoor: Within 5 percent RH.
5. Level: Within 5 percent of reading.
6. Pressure:
   a. Air, Ducts and Equipment: 0.5 percent of instrument span.
   b. Space: Within 0.5 percent of instrument span.
7. Speed: Within 5 Insert number percent of reading.
8. Temperature, Dry Bulb:
   a. Air: Within 0.5 deg F Insert value.
   b. Space: Within 0.5 deg F.
   c. Outdoor: Within 1 deg F.
   d. Temperature Difference: Within 0.25 deg F.
   e. Other Temperatures Not Indicated: Within 0.5 deg F.
9. Temperature, Wet Bulb:
   a. Air: Within 0.5 deg F.
   b. Space: Within 1 deg F.
   c. Outdoor: Within 1 deg F.
10. Vibration: Within 5 percent of reading.

G. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:
   a. Milliamperes: Nearest 1/100th of a milliampere.
   b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.
2. Energy:
   a. Electric Power:
      1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
      2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
      3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.
   b. Thermal, Rate:
      1) Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh.
      2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons.
   c. Thermal, Usage:
      1) Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu.
      2) Cooling: For ton-hours, nearest ton-hours up to 1000 ton-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons.
3. Flow:
   a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm.
4. Gas:
   a. Carbon Dioxide (ppm): Nearest ppm.
   b. Carbon Monoxide (ppm): Nearest ppm.
   c. Oxygen (Percentage): Nearest 1/10th of 1 percent.

5. Moisture (Relative Humidity):
    a. Relative Humidity (Percentage): Nearest 1 percent.
6. Level: Nearest 1/100th of an inch through 10 inches; nearest 1/10 of an inch between 10 and 100 inches; nearest inch above 100 inches.
7. Speed:
    a. Rotation (rpm): Nearest 1 rpm.
    b. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm.
8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
9. Pressure:
    a. Air, Ducts and Equipment: Nearest 1/10th in. w.c.
    b. Space: Nearest 1/100th in. w.c.
10. Temperature:
    a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
    b. Outdoor: Nearest degree.
    c. Space: Nearest 1/10th of a degree.
11. Vibration: Nearest 1/10th in/s.
12. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

H. Control Stability: Control variables indicated within the following limits:
1. Flow:
    a. Air, Ducts and Equipment, except Terminal Units: Within 2 percent of design flow rate.
    b. Air, Terminal Units: Within 5 percent of design flow rate.
2. Gas:
    a. Carbon Dioxide: Within 50 ppm.
    b. Carbon Monoxide: Within 5 percent of reading.
    c. Oxygen: Within 5 percent of reading.
3. Moisture (Relative Humidity):
    a. Air: Within 5 percent RH.
    b. Space: Within 5 percent RH.
    c. Outdoor: Within 5 percent RH.
4. Level: Within 2 Insert number percent of reading.
5. Pressure:
    a. Air, Ducts and Equipment: 0.5 percent of instrument span.
    b. Space: Within 0.5 percent of instrument span.

6. Temperature, Dew Point:
   a. Air: Within 0.5 deg F.
   b. Space: Within 0.5 deg F.
7. Temperature, Dry Bulb:
   a. Air: Within 0.5 deg F.
   b. Space: Within 0.5 deg F.
8. Temperature, Wet Bulb:
   a. Air: Within 0.5 deg F.
   b. Space: Within 0.5 deg F.

I. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
   a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.
2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
   a. Outdoors, Protected: Type 3.
   b. Outdoors, Unprotected: Type 4.
   c. Indoors, Heated with Filtered Ventilation: Type 1.
   d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
   e. Indoors, Heated and Air Conditioned: Type 1.
   f. Localized Areas Exposed to Washdown: Type 4X.
   g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
   h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
   i. Hazardous Locations: Explosion-proof rating for condition.

J. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
    a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.
2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
    a. Outdoors, Protected: Type 3.
    b. Outdoors, Unprotected: Type 4.
    c. Indoors, Heated with Filtered Ventilation: Type 1.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
    e. Indoors, Heated and Air-conditioned: Type 1.
    f. Localized Areas Exposed to Washdown: Type 4X.
    g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
    h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
    i. Hazardous Locations: Explosion-proof rating for condition.

K. DDC System Reliability:
1. Design, install and configure DDC controllers, gateways, routers, to yield a MTBF of at least 40,000 hours, based on a confidence level of at least 90 percent. MTBF value shall include any failure for any reason to any part of products indicated.
2. If required to comply with MTBF indicated, include DDC system and product redundancy to maintain DCC system, and associated systems and equipment that are being controlled, operational and under automatic control.
3. Critical systems and equipment that require a higher degree of DDC system redundancy than MTBF indicated shall be indicated on Drawings.

L. Electric Power Quality:
1. Power-Line Surges:

a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.

b. Do not use fuses for surge protection.

c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.

2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.

2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.

3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.

4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

M. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

N. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 PANEL-MOUNTED, MANUAL OVERRIDE SWITCHES

A. Manual Override of Control Dampers:

1. Include a two-position, selector switch for each automatic control damper being controlled by DDC controller.
2. Label each switch with damper designation served by switch.
3. Label switch positions to indicate either "Manual" or "Auto" control signal to damper.
4. With switch in "Auto" position signal to control damper actuator shall be control loop output signal from DDC controller.
5. With switch in "Manual" position, signal to damper actuator shall be controlled at panel with either an integral or separate switch to include local control.
   a. For Binary Control Dampers: Manual two-position switch shall have "Close" and "Open" switch positions indicated. With switch in "Close" position, damper shall close. With switch in "Open" position, damper shall open.
   b. For Analog Control Dampers: A gradual switch shall have "Close" and "Open" switch limits indicated. Operator shall be able to rotate switch knob to adjust damper to any position from close to open.
6. DDC controller shall monitor and report position of each manual override selector switch. With switch placed in "manual" position, DDC controller shall signal an override condition to alert operator that damper is under manual, not automatic, control.
7. Configure manual override switches to allow operator to manually operate damper while at panel without DDC controller installed and operational.
8. Terminal equipment including VAV units, fan-coil units, and unit heaters do not require manual override unless otherwise indicated by sequence of operation.

2.6 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two or three levels of LANs.

1. Level one LAN shall connect network controllers and operator workstations.
2. Level one or Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
3. Level two or Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.
4. Level two or Level three LAN shall connect application-specific controllers to application-specific controllers.

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: 100 Mbps.
2. LAN Connecting Programmable Application Controllers: 1000 kbps.

3. LAN Connecting Application-Specific Controllers: 115,000 bps.

C. DDC system shall consist of dedicated and separated LANs that are not shared with other building systems and tenant data and communication networks.

D. System architecture shall be modular and have inherent ability to expand to not less than two times system size indicated with no impact to performance indicated.

E. System architecture shall perform modifications without having to remove and replace existing network equipment.

F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

H. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.7 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable operator workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. PDA with wireless connection through LAN router.
5. Remote connection using outside of system personal computer or PDA through Web access.
6. Remote connection using portable operator workstation and telephone dial-up modem.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable operator workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Each boiler room.
3. Each chiller room or outdoor chiller yard.

4. Each cooling tower location.
5. Each different roof level with roof-mounted air-handling units or rooftop units.
6. Security system command center.
7. Fire-alarm system command center.

D. Desktop Workstations:
1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Able to communicate, with modems, remotely with any device connected to any DDC system LAN.
4. Communication via a modem shall not interfere with LAN activity and LAN activity shall not prevent workstation from handling incoming calls.

E. Portable Workstations:
1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system Level two or Level three LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Connect to system through a wireless router connected to Level one LAN.
5. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
6. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
7. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:
1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected or with LAN or connected to DDC system.

G. Personal Digital Assistant:
1. Connect to system through a wireless router connected to LAN.
2. Able to communicate with any DDC controller connected to DDC system.

H. Telephone Communications:
1. Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.

2. Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.
    a. Desktop and Portable Operator Workstation Computers with Modems:
        1) Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.
        2) Have routines to automatically answer calls, and either file or display information sent remotely.
        3) Communications taking place over telephone lines shall be completely transparent to operator.
        4) Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers so it is not required to remember or manually dial telephone numbers.
    b. DDC Controllers:
        1) Not have modems unless specifically indicated for a unique controller.
        2) Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.
        3) Analyze and prioritize alarms to minimize initiation of calls.
        4) Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.
        5) Make provisions for handling busy signals, no-answers, and incomplete data transfers.
        6) Call default devices when communications cannot be established with primary devices.

I. Critical Alarm Reporting:
    1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
    2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
    3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

J. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.8 NETWORKS

A. Acceptable networks for connecting operator workstations and network controllers include the following:
   1. ATA 878.1, ARCNET.
   2. IP.
   3. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:
   1. ATA 878.1, ARCNET.
   2. IP.
   3. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:
   1. ATA 878.1, ARCNET.
   2. EIA-485A.
   3. IP.
   4. IEEE 8802-3, Ethernet.

2.9 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to public and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:
   1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
   2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
   3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
   4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. Industry Standard Protocols:
   1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
      a. ASHRAE 135.

2. Operator workstations and network controllers shall communicate through ASHRAE 135 protocol.
3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
4. Gateways shall be used to connect networks and network devices using different protocols.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:
1. Existing server and operator workstation software shall be used. Provide additional licenses or upgrades as necessary for the added points and controllers.

2.11 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:
1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.12 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F.
3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F.

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within36 inches of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:
   a. Network Controllers: 50 percent.
   b. Programmable Application Controllers: Not less than 60 percent.
   c. Application-Specific Controllers: Not less than 70 percent.
2. Memory shall support DDC controller's operating system and database and shall include the following:
   a. Monitoring and control.
   b. Energy management, operation and optimization applications.
   c. Alarm management.
   d. Historical trend data of all connected I/O points.
   e. Maintenance applications.
   f. Operator interfaces.
   g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:
   a. 20 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: Three.
      2) AOs: Three.
      3) BIs: Five.
      4) BOs: Five.
2. Programmable Application Controllers:
   a. 10 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: Two.
      2) AOs: Two.
      3) BIs: Three.
      4) BOs: Three.
3. Application-Specific Controllers:
   a. 10 percent of each AI, AO, BI, and BO point connected to controller.
   b. Minimum Spare I/O Points per Controller:
      1) AIs: One.
      2) AOs: One.
      3) BIs: One.
      4) BOs: One.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:
1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. Input and Output Point Interface:
1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 Insert value bits or better to comply with accuracy requirements indicated.
d. Signal conditioning including transient rejection shall be provided for each AI.
e. Capable of being individually calibrated for zero and span.
f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:
a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 Insert value bits or better to comply with accuracy requirements indicated.
b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:
a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.
   1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
   2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.

c. BOs shall be selectable for either normally open or normally closed operation.

d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.

e. Use of three-point floating devices to control devices is not permitted.

2.13 NETWORK CONTROLLERS

A. General Network Controller Requirements:
   1. Include adequate number of controllers to achieve performance indicated.
   2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
   3. Controller shall have enough memory to support its operating system, database, and programming requirements.
   4. Data shall be shared between networked controllers and other network devices.
   5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
   6. Controllers that perform scheduling shall have a real-time clock.
   7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
   8. Controllers shall be fully programmable.

B. Communication:
   1. Network controllers shall communicate with other devices on DDC system Level one network.
   2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:
1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or PDA.
2. Local Keypad and Display:
a. Equip controller with local keypad and digital display for interrogating and editing data.
b. Use of keypad and display shall require security password.

D. Serviceability:
1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 96 hours.

2.14 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:
1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:
1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:
1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or PDA.
2. Local Keypad and Display:

a. Equip controller with local keypad and digital display for interrogating and editing data.

b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.15 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.16 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.

2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:
1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:
1. Weekly Schedule:
   a. Include separate schedules for each day of week.
   b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
   c. Each schedule may consist of up to 10 events.
   d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.
2. Exception Schedules:
   a. Include ability for operator to designate any day of the year as an exception schedule.
   b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.
3. Holiday Schedules:
   a. Include capability for operator to define up to 99 special or holiday schedules.
   b. Schedules may be placed on scheduling calendar and will be repeated each year.
   c. Operator shall be able to define length of each holiday period.

D. System Coordination:
1. Include standard application for proper coordination of equipment.

2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:
1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:
1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:
1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:
1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:
1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Demand reduction shall be accomplished by the following means:
   a. Reset air-handling unit supply temperature set points.
   b. Reset space temperature set points.
   c. De-energize equipment based on priority.
4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.

6. Include means operator to make the following changes online:
   a. Addition and deletion of loads controlled.
   b. Changes in demand intervals.
   c. Changes in demand limit for meter(s).
   d. Maximum shutoff time for equipment.
   e. Minimum shutoff time for equipment.
   f. Select rotational or sequential shedding and restoring.
   g. Shed and restore priority.
7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:
   a. Total electric consumption.
   b. Peak demand.
   c. Date and time of peak demand.
   d. Daily peak demand.

J. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

K. Control Loops:
1. Support any of the following control loops, as applicable to control required:
   a. Two-position (on/off, open/close, slow/fast) control.
   b. Proportional control.
   c. Proportional plus integral (PI) control.
   d. Proportional plus integral plus derivative (PID) control.
      1) Include PID algorithms with direct or reverse action and anti-windup.
      2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
      3) Controlled variable, set point, and PID gains shall be operator-selectable.
   e. Adaptive (automatic tuning).

L. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

M. Energy Calculations:
1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.

2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

N. Anti-Short Cycling:
1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

O. On and Off Control with Differential:
1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

P. Run-Time Totalization:
1. Include software to totalize run-times for all BI and BO points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.17 ENCLOSURES

A. General Enclosure Requirements:
1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Individual wall-mounted single-door enclosures shall not exceed 36 inches wide and 48 inches high.
6. Individual wall-mounted double-door enclosures shall not exceed 60 inches wide and 36 inches high.
7. Freestanding enclosures shall not exceed 48 inches wide and 72 inches high.
8. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
9. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door.

B. Internal Arrangement:
   1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
   2. Arrange layout to group similar products together.
   3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
   4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
   5. Terminate field cable and wire using heavy-duty terminal blocks.
   6. Include spare terminals, equal to not less than 10 percent of used terminals.
   7. Include spade lugs for stranded cable and wire.
   8. Install a maximum of two wires on each side of a terminal.
   9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
   10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
   11. Mount products within enclosure on removable internal panel(s).
   12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch- high lettering.
   13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
   14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
   15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:
   1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
   2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
   3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.

4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.
5. Include temperature-controlled cooling within the enclosure for applications where ventilation fans cannot maintain inside temperature of enclosure below maximum operating temperature of product with most stringent requirement.
6. Where required by application, include humidity-controlled electric dehumidifier or cooling to maintain inside of enclosure below maximum relative humidity of product with most stringent requirement and to prevent surface condensation within enclosure.

D. Wall-Mounted, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Hoffman; a brand of Pentair Equipment Protection.
   b. OR Approved Equal
2. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
3. Construct enclosure of steel, not less than:
   a. Enclosure size less than 24 in.: 0.053 in. thick.
   b. Enclosure size 24 in. and larger: 0.067 in. thick.
4. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Exterior color shall be NSF/ANSI 61 gray.
   b. Interior color shall be NSF/ANSI 61 gray.
5. Hinged door full size of front face of enclosure and supported using:
   a. Enclosures sizes less than 36 in. tall: Multiple butt hinges.
   b. Enclosures sizes 36 in. tall and larger: Continuous piano hinges.
6. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Size less than 24 in.: Solid or Perforated steel, 0.053 in. thick.
   b. Size 24 in. and larger: Solid aluminum, 0.10 in. thick.
7. Internal panel mounting hardware, grounding hardware and sealing washers.
8. Grounding stud on enclosure body.
9. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Hoffman; a brand of Pentair Equipment Protection.
2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
5. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
6. Single-door enclosure sizes up to 60 inches tall by 36 inches wide.
7. Double-door enclosure sizes up to 36 inches tall by 60 inches wide.
8. Construct enclosure of steel, not less than the following:
   a. Size Less Than 24 Inches: 0.053 inch thick.
   b. Size 24 Inches and Larger: 0.067 inch thick.
9. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Exterior color shall be NSF/ANSI 61 gray.
   b. Interior color shall be NSF/ANSI 61 gray.
10. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
    a. Sizes through 24 Inches Tall: Two hinges.
    b. Sizes between 24 Inches through 48 Inches Tall: Three hinges.
    c. Sizes Larger 48 Inches Tall: Four hinges.
11. Double-door enclosures with overlapping door design to include unobstructed full-width access.
    a. Single-door enclosures 48 inches and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.
12. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    a. Size Less Than 24 Inches: Solid or perforated steel, 0.053 inch thick.
    b. Size 24 Inches and Larger: Solid aluminum, 0.10 inch thick.
13. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
14. Grounding stud on enclosure body.
15. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Wall-Mounted, NEMA 250, Type 4X SS:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Hoffman; a brand of Pentair Equipment Protection.
2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Construct enclosure of Type 304 stainless steel, not less than the following:
   a. Size Less Than 24 Inches: 0.053 inch thick.
   b. Size 24 Inches and Larger: 0.067 inch thick.
6. Outside body and door of enclosure with brushed No. 4 finish.
7. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.
   a. Sizes through 24 InchesTall: Two hinges.
   b. Sizes between 24 Inchesthrough 48 InchesTall: Three hinges.
   c. Sizes Larger 48 InchesTall: Four hinges.
8. Corner-formed door, full size of enclosure face, supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with single, heavy-duty, liquid-tight Type 316 stainless-steel handle with integral locking mechanism.
10. Removable internal panel shall be 0.093-inch solid steel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs and hardware, grounding hardware, and sealing washers.
12. Install corrosion-resistant polyester vent drain in a stainless-steel sleeve at the bottom of enclosure.
13. Include enclosure with stainless-steel mounting brackets.

G. Freestanding, NEMA 250, Type 1:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Hoffman; a brand of Pentair Equipment Protection.
2. Enclosure shall be NRTL listed according to UL 508A.
3. Seam and joints are continuously welded and ground smooth.

4. Externally formed body flange around perimeter of enclosure face.
5. Single-door enclosure sizes up to 84 inches tall by 36 inches wide.
6. Double-door enclosure sizes up to 84 inches tall by 72 inches wide.
7. Construct enclosure of steel, not less than 0.067 inch thick.
8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
    a. Exterior color shall be NSF/ANSI 61 gray.
    b. Interior color shall be NSF/ANSI 61 gray.
9. Corner-formed flush door, full size of enclosure face, supported using four concealed hinges with easily removable hinge pins.
10. Double-door enclosures with overlapping door design to include unobstructed full-width access.
11. Doors with three-point (top, middle, and bottom) latch system with single heavy-duty handle and integral locking mechanism.
12. Removable back covers.
13. Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
14. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
15. Grounding stud on enclosure body.
16. Thermoplastic pocket on inside of door for record Drawings and Product Data.
17. Nominal 4-inch- tall integral lifting base, not less than 0.123 inch thick, with predrilled holes for attachment to mounting surface.
18. Each top end of enclosure fitted with lifting tabs, not less than 0.172 inch thick.
19. Internal rack-mount shelves and angles as required by application.

H. Freestanding, NEMA 250, Types 4 and 12:
1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Externally formed body flange around perimeter of enclosure face.
4. Type 12 Enclosure Sizes:
    a. Single-door enclosure sizes up to 90 inches tall by 36 inches wide.
    b. Double-door enclosure sizes up to 90 inches tall by 72 inches wide.
5. Type 4 Enclosure Sizes:
    a. Single-door enclosure sizes up to 72 inches tall by 36 inches wide.
6. Construct enclosure of steel, not less than 0.093 inch thick.

7. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.
   a. Exterior color shall be NSF/ANSI 61 gray.
   b. Interior color shall be NSF/ANSI 61 gray.
8. Corner-formed door with continuous perimeter oil-resistant gasket supported using continuous piano hinge full length of door.
9. Doors fitted with three-point (top, middle, and bottom) latch system with latching rod rollers and single, heavy-duty oil-tight handle with integral locking mechanism.
10. Removable solid steel internal panel, 0.093 inch thick, with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.
11. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
12. Grounding stud on enclosure body.
13. Thermoplastic pocket on inside of door for record Drawings and Product Data.
14. Top of enclosure fitted with no fewer than two lifting eyes.
15. Internal rack-mount shelves and angles as required by application.

I. Accessories:
1. Electric Heater:
   a. Aluminum housing with brushed finish.
   b. Thermostatic control with adjustable set point from zero to 100 deg F.
   c. Capacity: 100, 200, 400, and 800 W as required by application.
   d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.
2. Ventilation Fans, Filtered Intake and Exhaust Grilles:
   a. Number and size of fans, filters and grilles as required by application.
   b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
   c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
   d. Thermostatic control with adjustable set point from 32 to 140 deg F.
   e. Airflow Capacity at Zero Pressure:
      1) 4-Inch Fan: 100 cfm.
      2) 6-Inch Fan: 240 cfm.
      3) 10-Inch Fan: 560 cfm.
   f. Maximum operating temperature of 158 deg F.

g. 4-inch fan thermally protected and provided with permanently lubricated ball-bearings.
h. 6-and 10-inch fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
i. Dynamically balanced impellers molded from polycarbonate material.
j. Fan furnished with power cord and polarized plug for power connection.
k. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
l. Removable Intake and Exhaust Grilles: ABS plastic or stainless steel of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
m. Filters for NEMA 250, Type 1 Enclosures: Washable foam or aluminum, of a size to match intake grille.
n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

3. Air Conditioner:
a. Electric-powered, self-contained air-conditioning unit specially designed for electrical enclosures to maintain temperature inside enclosure below ambient temperature outside enclosure.
b. Thermostatic control with adjustable set point from 60 to 120 deg F.
c. Enclosure side or top mounting with unit capacity as required by application.
d. Designed for closed-loop cooling with continuous operation in ambient environments up to 125 deg F.
e. HFC refrigerant.
f. Reusable and washable air filter.
g. High-performance, industrial-grade, and high-efficiency fans.
h. Furnished with power cord and polarized plug for power connection.
i. Condensate management system with base pan side drain.
j. Mounting hardware, gaskets, mounting template and instruction manual furnished with unit.
k. Outdoor units equipped with head pressure control for low ambient operation, compressor heater, coated condenser coil and thermostat.

4. Thermoelectric Humidifier:
a. ABS plastic enclosure.
b. Capacity of 8 oz. of water per 24 hours.

c. Built-in drain captures moisture and plastic hose directs moisture to outside enclosure through a drain.

d. Controlled to maintain enclosure relative humidity at an adjustable set point.

e. Unit power supply shall be internally wired to enclosure electrical power source.

5. Bar handle with keyed cylinder lock set.

2.18 RELAYS

A. General-Purpose Relays:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Siemens Building Technologies, Inc.

2. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.

3. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.

4. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.

5. Construct the contacts of either silver cadmium oxide or gold.

6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.

7. Relays shall have LED indication and a manual reset and push-to-test button.

8. Performance:

a. Mechanical Life: At least 10 million cycles.

b. Electrical Life: At least 100,000 cycles at rated load.

c. Pickup Time: 15 ms or less.

d. Dropout Time: 10 ms or less.

e. Pull-in Voltage: 85 percent of rated voltage.

f. Dropout Voltage: 50 percent of nominal rated voltage.

g. Power Consumption: 2 VA.

h. Ambient Operating Temperatures: Minus 40 to 115 deg F.

9. Equip relays with coil transient suppression to limit transients to non-damaging levels.

10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.

11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Siemens Building Technologies, Inc.
2. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
3. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
4. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
5. Construct the contacts of either silver cadmium oxide or gold.
6. Enclose the relay in a dust-tight cover.
7. Include knob and dial scale for setting delay time.
8. Performance:
   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
   d. Repeatability: Within 2 percent.
   e. Recycle Time: 45 ms.
   f. Minimum Pulse Width Control: 50 ms.
   g. Power Consumption: 5 VA or less at 120-V ac.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Siemens Building Technologies, Inc.
2. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
3. Relays shall be either DPDT or three-pole double throw, depending on the control application.
4. Use a plug-in-style relay with a multibladed plug.
5. Construct the contacts of either silver cadmium oxide or gold.

6. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
7. Performance:
   a. Mechanical Life: At least 10 million cycles.
   b. Electrical Life: At least 100,000 cycles at rated load.
   c. Pickup Time: 15 ms or less.
   d. Dropout Time: 10 ms or less.
   e. Pull-in Voltage: 85 percent of rated voltage.
   f. Dropout Voltage: 50 percent of nominal rated voltage.
   g. Power Consumption: 2 VA.
   h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Square D; by Schneider Electric.
2. Monitors ac current.
3. Independent adjustable controls for pickup and dropout current.
4. Energized when supply voltage is present and current is above pickup setting.
5. De-energizes when monitored current is below dropout current.
6. Dropout current is adjustable from 50 to 95 percent of pickup current.
7. Include a current transformer, if required for application.
8. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Functional Devices Inc.
2. Description:
   a. On-off control and status indication in a single device.

b. LED status indication of activated relay and current trigger.

c. Closed-Open-Auto override switch located on the load side of the relay.

3. Performance:

a. Ambient Temperature: Minus 30 to 140 deg F.

b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

4. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.

b. Current Sensor Range: As required by application.

c. Current Set Point: Fixed or adjustable as required by application.

d. Current Sensor Output:

1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.

2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.

3) Analog, zero- to 5- or 10-V dc.

4) Analog, 4 to 20 mA, loop powered.

5. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.

6. Enclosure: NEMA 250, Type 1 enclosure.

2.19 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.

2. Transformer shall be at least 100 VA.

3. Transformer shall have both primary and secondary fuses.

B. Power-Line Conditioner:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Controlled Power Company; an Emerson company.

2. General Power-Line Conditioner Requirements:

a. Design to ensure maximum reliability, serviceability and performance.

b. Overall function of the power-line conditioner is to receive raw, polluted electrical power and purify it for use by electronic equipment. The power-line conditioner shall provide isolated, regulated, transient and noise-free sinusoidal power to loads served.

3. Standards: NRTL listed per UL 1012.

4. Performance:

a. Single phase, continuous, 100 percent duty rated KVA/KW capacity. Design to supply power for linear or nonlinear, high crest factor, resistive and reactive loads.

b. Automatically regulate output voltage to within 2 percent or better with input voltage fluctuations of plus 10 to minus 20 percent of nominal when system is loaded 100 percent. Use Variable Range Regulation to obtain improved line voltage regulation when operating under less than full load conditions.

1) At 75 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 35 percent of nominal.

2) At 50 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 40 percent of nominal.

3) At 25 Percent Load: Output voltage automatically regulated to within 3 percent with input voltage fluctuations of plus 10 to minus 45 percent of nominal.

c. With input voltage distortion of up to 40 percent, limit the output voltage sine wave to a maximum harmonic content of 5 percent.

d. Automatically regulate output voltage to within 2.5 percent when load (resistive) changes from zero percent to 100 percent to zero percent.

e. Output voltage returns to 95 percent of nominal level within two cycles and to 100 percent within three cycles when the output is taken from no load to full resistive load or vice-versa. Recovery from partial resistive load changes is corrected in a shorter period of time.

f. K Factor: 30, designed to operate with nonlinear, non-sinusoidal, high crest factor loads without overheating.

g. Input power factor within 0.95 approaching unity with load power factor as poor as 0.6.

h. Attenuate load-generated odd current harmonics 23 dB at the input.

i. Electrically isolate the primary from the secondary. Meet isolation criteria as defined in NFPA 70, Article 250-5D.

j. Lighting and Surge Protection: Compares to UL 1449 rating of 330 V when subjected to Category B3 (6000 V/3000 A) combination waveform as established by IEEE C62.41.

k. Common-mode noise attenuation of 140 dB.

l. Transverse-mode noise attenuation of 120 dB.

m. With loss of input power for up to 16.6 ms, the output sine wave remains at usable ac voltage levels.

n. Reliability of 200,000 hours' MTBF.

o. At full load, when measured at 1-m distance, audible noise is not to exceed 54 dB.

p. Approximately 92 percent efficient at full load.

5. Transformer Construction:

a. Ferroresonant, dry type, convection cooled, 600V class. Transformer windings of Class H (220 deg C) insulated copper.

b. Use a Class H installation system throughout with operating temperatures not to exceed 150 deg C over a 40-deg C ambient temperature.

c. Configure transformer primary for multi-input voltage. Include input terminals for source conductors and ground.

d. Manufacture transformer core using M-6 grade, grain-oriented, stress-relieved transformer steel.

e. Configure transformer secondary in a 240/120-V split with a 208-V tap or straight 120 V, depending on power output size.

f. Electrically isolate the transformer secondary windings from the primary windings. Bond neutral conductor to cabinet enclosure and output neutral terminal.

g. Include interface terminals for output power hot, neutral and ground conductors.

h. Label leads, wires and terminals to correspond with circuit wiring diagram.

i. Vacuum impregnate transformer with epoxy resin.

6. Cabinet Construction:

a. Design for panel or floor mounting.

b. NEMA 250, Type 1, general-purpose, indoor enclosure.

c. Manufacture the cabinet from heavy gauge steel complying with UL 50.

d. Include a textured baked-on paint finish.

C. Transient Voltage Suppression and High-Frequency Noise Filter Unit:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

a. Current Technology Inc.

2. The maximum continuous operating voltage shall be at least 125 percent.

3. The operating frequency range shall be 47 to 63 Hz.

4. Protection modes according to NEMA LS-1.
5. The rated single-pulse surge current capacity, for each mode of protection, shall be no less than the following:
    a. Line to Neutral: 45,000 A.
    b. Neutral to Ground: 45,000 A.
    c. Line to Ground: 45,000 A.
    d. Per Phase: 90,000 A.
6. Clamping voltages shall be in compliance with test and evaluation procedures defined in NEMA LS-1. Maximum clamping voltage shall be as follows:
    a. Line to Neutral: 360 V.
    b. Line to Ground: 360 V.
    c. Neutral to Ground: 360 V.
7. Electromagnetic interference and RF interference noise rejection or attenuation values shall comply with test and evaluation procedures defined in NEMA LS-1.
    a. Line to Neutral:
        1) 100 kHz: 42 dB.
        2) 1 MHz: 25 dB.
        3) 10 MHz: 21 dB.
        4) 100 MHz: 36 dB.
    b. Line to Ground:
        1) 100 kHz: 16 dB.
        2) 1 MHz: 55 dB.
        3) 10 MHz: 81 dB.
        4) 100 MHz: 80 dB.
8. Unit shall have LED status indicator that extinguishes to indicate a failure.
9. Unit shall be listed by an NRTL as a transient voltage surge suppressor per UL 1449, and as an electromagnetic interference filter per UL 1283.
10. Unit shall not generate any appreciable magnetic field.
11. Unit shall not generate an audible noise.

D. DC Power Supply:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
    a. Acopian Technical Company.

2. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
3. Enclose circuitry in a housing.
4. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
5. Performance:
   a. Output voltage nominally 25-V dc within 5 percent.
   b. Output current up to 100 mA.
   c. Input voltage nominally 120-V ac, 60 Hz.
   d. Load regulation within 0.5 percent from zero- to 100-mA load.
   e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
   f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.20 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

A. 250 through 1000 VA:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. APC.
   b. Oneac-Powervar Solutions; Powervar, Inc.
2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
   a. Larger-capacity units shall be provided for systems with larger connected loads.
   b. UPS shall provide five minutes of battery power.
4. Performance:
   a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
   b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
   c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
   d. On Battery Output Voltage: Sine wave.
   e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
   f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
   g. Transfer Time: 6 ms.

h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

5. UPS shall be automatic during fault or overload conditions.

6. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.

7. Include front panel with power switch and visual indication of power, battery, fault and temperature.

8. Unit shall include an audible alarm of faults and front panel silence feature.

9. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.

10. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.

11. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.

12. Include tower models installed in ventilated cabinets to the particular installation location.

B. 1000 through 3000 VA:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. APC.

b. Toshiba International Corporation.

2. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.

3. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.

b. UPS shall provide five minutes of battery power.

4. Performance:

a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.

b. Power Factor: Minimum 0.97 at full load.

c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.

d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.

e. Recharge time shall be a maximum of eight hours to 90 percent capacity.

5. UPS bypass shall be automatic during fault or overload conditions.

6. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.
7. Batteries shall be sealed lead-acid type and be maintenance free.
8. Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration.

2.21 PIPING AND TUBING

A. Pneumatic, and Pressure Instrument Signal Air, Tubing and Piping:

1. Products in this paragraph are intended for use with the following:
   a. Main air and signal air to pneumatically controlled instruments, actuators and other control devices and accessories.
   b. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers and accessories.
2. Copper Tubing:
   a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B 75.
   b. Performance, dimensions, weight and tolerance according to ASTM B 280.
   c. Diameter, as required by application, not less than nominal 0.25 inch.
   d. Wall thickness, as required by the application, but not less than 0.030 inch.
3. Copper Tubing Connectors and Fittings:
   a. Brass, compression type.
      1) Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
         a) Parker Hannifin Corporation.
4. Galvanized-Steel Piping:
   a. Galvanized pipe shall be ASTM A 53/A 53M, Schedule 40.
   b. Fittings, galvanized malleable iron, ASME B16.3, Class 150.
5. Polyethylene Tubing:
   a. Fire-resistant black virgin polyethylene according to ASTM D 1248, Type 1, Class C and Grade 5.
   b. Tubing shall comply with stress crack test according to ASTM D 1693.
   c. Diameter, as required by application, of not less than nominal 0.25 inch.
6. Polyethylene Tubing Connectors and Fittings:
   a. Brass, barbered fittings.
   b. Brass, compression type.

B. Process Tubing:

1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.
2. Copper Tubing:
   a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B 75.
   b. Performance, dimensions, weight and tolerance according to ASTM B 280.
   c. Diameter, as required by application, of not less than nominal 0.25 inch.
   d. Wall thickness, as required by application, but not less than 0.030 inch.
3. Copper Tubing Connectors and Fittings:
   a. Brass, compression type.
      1) Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
         a) Parker Hannifin Corporation.
   b. Brass, solder-joint type.
      1) Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
         a) Parker Hannifin Corporation.

2.22 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size shall be at least No. 18 AWG.
2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size shall be a minimum No. 20 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.

6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:
1. Wire size shall be a minimum No. 20 AWG.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
1. Cable shall be plenum rated.
2. Cable shall comply with NFPA 70.
3. Cable shall have a unique color that is different from other cables used on Project.
4. Copper Cable for Ethernet Network:
a. 100BASE-TX 1000BASE-T or 1000BASE-TX.
b. TIA/EIA 586, Category 6.
c. Minimum No. 22 AWG solid.
d. Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP).
e. Thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, Class CMP as plenum rated.

2.23 RACEWAYS FOR CONTROL WIRING, CABLING, AND TUBING

A. Metal Conduits, Tubing, and Fittings:
1. Refer to 260533 for list of acceptable manufacturers
2. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with NEMA ANSI C80.1 and UL 6.

4. ARC: Comply with NEMA ANSI C80.5 and UL 6A.
5. IMC: Comply with NEMA ANSI C80.6 and UL 1242.
6. PVC-Coated Steel Conduit: PVC-coated.
   a. Comply with NEMA RN 1.
   b. Coating Thickness: 0.040 inch, minimum.
7. EMT: Comply with NEMA ANSI C80.3 and UL 797.
8. FMC: Comply with UL 1; zinc-coated steel.
9. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
10. Fittings for Metal Conduit: Comply with NEMA ANSI FB 1 and UL 514B.
    a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
    b. Fittings for EMT:
       1) Material: Steel.
       2) Type: compression.
    c. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
    d. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.
11. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

B. Metal Wireways and Auxiliary Gutters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. B-line, an Eaton business.
   b. Hoffman; a brand of Pentair Equipment Protection.
   c. Square D; by Schneider Electric.
2. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R or Type 4 as required by the location and unless otherwise indicated, and sized according to NFPA 70.
   a. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
4. Wireway Covers: Screw-cover or Flanged-and-gasketed type unless otherwise indicated.
5. Finish: Manufacturer's standard enamel finish.

C. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Prime coated, ready for field painting.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Panduit Corp.
   b. Wiremold / Legrand.

2.24 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.

B. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.25 FIBER-OPTIC CABLE, CONNECTORS, AND RACEWAY

A. Cables:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMP NETCONNECT; a TE Connectivity Ltd. company.
   b. Belden Inc.
   c. Communications Specialties, Inc.
   d. Corning Cable Systems.
2. Performance Requirements:
   a. Fiber: Multimode graded index. Core/cladding size shall be either 62.5/125 or 100/140 micrometers.
   b. Numerical Aperture:
      1) 62.5/125 Micrometer Fiber: 0.275 plus or minus 0.015.
      2) 100/140 Micrometer Fiber: 0.29 plus or minus 0.015.
   c. Maximum Attenuation:
      1) 850 nm: 6.0 dB/km.
      2) 1300 nm: 5.0 dB/km.
   d. Minimum Bandwidth Dispersion: 300 MHz-km at 850 nm.

e. Core/Cladding Index Difference: 0.3 percent plus or minus 0.05 percent, measured using refractive rear field measurement procedure.

f. Color-code finished fibers for easy identification.

g. Splice Loss: Fibers shall be spliced together to form a longer fiber using a commercially available fiber splicing machine recommended by cable manufacturer. Maximum loss per fiber splice shall be 0.20 dB.

h. Connection: Fibers shall be connected using fiber-optic connectors. Nominal connector loss shall not be greater than 1 dB.

i. Fiber-optic cable shall be suitable for use with 100Base-FX or 100Base-SX standard (as applicable) as defined in IEEE 802.3.

3. Mechanical and Environmental Requirements:

a. Tensile Strength: Fiber cable shall withstand a minimum tensile strength of 2700 N with maximum elongation of less than 0.5 percent.

b. Bending Radius: Minimum static bending radius for cable shall be 10 times outside diameter for non-armored cables and 20 times outside diameter for armored cables. Non-armored cables shall withstand being flexed at minimum static bending radius plus or minus 90 degrees for at least 20 cycles at 20 to 40 cycles per minute at 20 deg C. Armored cables shall withstand being flexed at minimum static bending radius plus or minus 90 degrees for at least 10 cycles at 20 to 40 cycles per minute at 20 deg C

c. Vibration: Cable shall withstand a vibration test with vibration amplitude of 5 mm and frequency of 10 cycles per second for at least five hours.

d. Twist: Cable shall withstand twisting of 360 degrees over a length of 2 m for at least 10 cycles at 10 cycles per minute.

e. Temperature: Cable shall withstand the following temperatures:

1) Installation: Minus 30 to 70 deg C.

2) Operation: Minus 40 to 70 deg C.

3) Storage/Shipping: Minus 40 to 70 deg C.

f. Lifetime: Average lifetime of a 2-km, 12-fiber cable shall be at least 20 years when installed in a natural ambient environment. End of useful life shall be reached if failing to comply with requirements indicated or a spontaneous catastrophic fiber failure.

g. Crush Resistance: Cable shall withstand a compressive force of 705 N/cm for armored cables and 600 N/cm for non-armored cables. There shall be no attenuation increase after force is removed.

4. Cable Structure:

a. Number of Fibers: Supply the required number of fibers in each cable for DDC system indicated, plus not less than 50 percent spare. Cable structure shall have fibers grouped for easy handling.

b. Strength Members: Include cable with strength members to satisfy mechanical and environmental conditions indicated.

c. Cable Core: Core shall consist of stranded buffer tubes around a central member of appropriate geometric size and shall be filled and bound to maintain core integrity. A fibrous strength member may be stranded around core to provide necessary strength for cable.

d. Cable Jacket: Protect cable by an extruded-polyethylene jacket.

e. Cable Armor: For cables requiring extra mechanical protection, one or two layers of galvanized corrugated steel tape coated by an anticorrosive compound shall be either helically or longitudinally applied over standard outer jacket. Apply a second outer jacket of polyethylene over coated steel tape. Thickness of sheaths and jackets are not specified as long as mechanical and environmental conditions are satisfied.

f. Cable Installation: Cables shall be suitable for a semiprotected outdoor installation.

5. Packaging and Shipping:

a. Seal both ends of each length of cable.

b. Test individual fibers in each cable before shipping to verify compliance with Specifications.

B. Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. AMP NETCONNECT; a TE Connectivity Ltd. company.

b. Communications Specialties, Inc.

c. Corning Cable Systems.

2. Performance Requirements:

a. Type: Fiber-optic connectors shall be either Type ST or Type SMA. Use either connector type exclusively. No substitutions are allowed.

b. Insertion Loss: Connector shall have an insertion loss of not greater than 1 dB.

c. Coupling Tolerance: Connector shall withstand at least 500 couplings with insertion loss within 0.25-dB tolerance limit.

d. Mechanical Requirements:

1) Connector shall enclose outermost coating of single fiber cable and be able to be mated or unmated without using a tool.

2) Mount connector rigidly in a metal frame.

3) Connector shall allow a semiskilled person to properly install connector to a single fiber easily in a field environment with simple tools.

C. Splice Organizer Cabinet:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AMP NETCONNECT; a TE Connectivity Ltd. company.
   b. Communications Specialties, Inc.
   c. Corning Cable Systems.
2. Minimum Capacity: Each splice organizer shall accommodate number of connectors required for DDC system indicated, plus 100 percent spare.
3. Mounting: Wall mount the splice organizer cabinet.

D. Raceways:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Dura-Line.
   b. Pacific Plastics Inc.
2. Mechanical and Performance Requirements:
   a. Construction: Nonmetallic, flexible raceway system manufactured specifically for routing fiber-optic cables.
   b. Suitable for use in return-air plenums, air-handling rooms, above ceilings and under access floors.
   c. Exhibit low smoke generation and flame-spread characteristics, and have high-temperature service tolerance.
   d. Size raceway according to NFPA 70 requirements for communications cables.
   e. Tensile Strength at Yield: 10,800 psi.
   f. Elongation at Break: 25 percent.

E. Cable Identification:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Paul Mueller Company.
2. Labeling product shall be self-laminating cable marker.
3. Cable labeling shall include numeric designation, source, destination, and cable type.

2.26 ACCESSORIES

A. Pneumatic Pressure Gages:
   1. Pressure gages shall a 1.5-inch- diameter face for pressures up through 30 psig and 2.5-inch- diameter face for greater pressures.
   2. Include separate gages for branch pressure and main pressure lines.
   3. White dial face with black printing.
   4. Include 1-psig increment for scale ranges through 30 psig and 2-psig increment for larger ranges.
   5. Accuracy: Within 1 percent of full-scale range.

B. Pressure Electric Switches:
   1. Diaphragm-operated snap acting switch.
   2. Set point adjustable from 3 to 20 psig.
   3. Differential adjustable from 2 to 6 psig.
   4. Rated for resistance loads at 120-V ac.
   5. Body and switch housing shall be metal.

C. Damper Blade Limit Switches:
   1. Sense positive open and/or closed position of the damper blades.
   2. NEMA 250, Type 13, oil-tight construction.
   3. Arrange for the mounting application.
   4. Additional waterproof enclosure when required by its environment.
   5. Arrange to prevent "over-center" operation.

D. I/P and E/P Transducers:
   1. Commercial Grade:
      a. The transducer shall convert an AO signal to a stepped pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig pneumatic signal for pneumatic actuation.
      b. Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.
      c. Transducer shall have auto/manual output switch, manual output control and an output pressure gage.
      d. Accuracy: Within 1.0 percent of the output span.
      e. Linearity: Within 0.5 percent of the output span.
      f. Output Capacity: Not less than 550 scim at 15 psig.
      g. Transducer shall have separate zero and span calibration adjustments.
      h. The transducer shall withstand up to 40 psig of supply pressure without damage.

i. For use on only modulating pneumatic outputs that are associated with terminal units, including fan-coil units, VAV units, and unit heaters

E. E/P Switch:

1. Construct the body of cast aluminum or brass; three pipe body (common, normally open, and normally closed).
2. Internal construction of steel, copper or brass.
3. Air Connections: Barb.
4. Rating of 30 psig when installed in systems below 25 psig and of 150 psig when installed in systems above 25 psig.
5. Include coil transient suppression.

F. Instrument Enclosures:

1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
2. NRTL listed and labeled to UL 50.
3. Sized to include at least 25 percent spare area on subpanel.
4. Instrument(s) mounted within enclosure on internal subpanel(s).
5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.
8. Enclosures larger than 12 inches shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

G. Manual Valves:

1. Needle Type:
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      1) Parker Hannifin Corporation.
   b. PTFE packing.
   c. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
   d. Aluminum T-bar handle.
   e. Include tubing connections.

2. Ball Type:
   a. Manufacturers: Subject to compliance with requirements, provide products by the following:
      1) Apollo (Conbraco Inductries).
   b. Body: Bronze ASTM B 62 or ASTM B 61.
   c. Ball: Type 316 stainless steel.
   d. Stem: Type 316 stainless steel.
   e. Seats: Reinforced PTFE.
   f. Packing Ring: Reinforced PTFE.
   g. Lever: Stainless steel with a vinyl grip.
   h. 600 WOG.
   i. Threaded end connections.

2.27 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:
   1. Engraved tag bearing unique identification.
      a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
   2. Letter size shall be as follows:
      a. DDC Controllers: Minimum of 0.5 inch high.
      b. Gateways: Minimum of 0.5 inch high.
      c. Repeaters: Minimum of 0.5 inch high.
      d. Enclosures: Minimum of 0.5 inch high.
      e. Electrical Power Devices: Minimum of 0.25 inch high.
      f. UPS units: Minimum of 0.5 inch high.
      g. Accessories: Minimum of 0.25 inch high.
      h. Instruments: Minimum of 0.25 inch high.
      i. Control Damper and Valve Actuators: Minimum of 0.25 inch high.
   3. Tag shall consist of white lettering on black background.
   4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
   5. Tag shall be fastened with drive pins.
   6. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Valve Tags:
1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:
1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

D. Equipment Warning Labels:
1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.
1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

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

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. The DDC system shall be integrated with the existing DDC system at the main campus such that the new DDC system may be viewed and controlled from that existing system.

B. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.

2. Equipment to Be Connected:

a. Air-terminal units specified in Section 233600 "Air Terminal Units."

b. Roof-top units specified in Section 237416.13 "Packaged, Outdoor, Central-Station Air-Handling Units."

c. Packaged terminal air-conditioners specified in Section 238113.11 "Packaged Terminal Air-Conditioners, Through-Wall Units," Section 238113.12 "Packaged Terminal Air-Conditioners, Freestanding Units," and Section 238113.13 "Packaged Terminal Air-Conditioners, outdoor, wall-mounted units."

d. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."

3.3 DDC SYSTEM INTERFACE WITH EXISTING SYSTEMS

A. Interface with Existing Systems:

1. DDC systems shall interface existing systems to achieve integration.

2. Monitoring and Control of DDC System by Existing Control System:

a. DDC system performance requirements shall be satisfied when monitoring and controlling DDC system by existing control system.

b. Operator of existing system shall be able to upload, download, monitor, trend, control and program every input and output point in DDC system from existing control system using existing control system software and operator workstations.

c. Remote monitoring and control from existing control system shall not require operators of existing control system to learn new software.

d. Interface of DDC system into existing control system shall be transparent to operators of existing control system and allow operators to program, monitor, and control DDC system from any operator workstation connected to existing control system.

3. Integration of Existing Control System into DDC System:

a. Existing control system performance requirements shall be satisfied when monitoring and controlling existing control system through DDC system.

b. Operator shall be able to upload, download, monitor, alarm, report, trend, control and program every input and output point in existing system from DDC system using operator workstations and software provided. The combined systems shall share one database.

c. Interface of existing control system I/O points into DDC system shall be transparent to operators. All operational capabilities shall be identical regardless of whether I/O already exists or I/O is being installed.

B. Integration with Existing Enterprise System:

1. DDC system shall interface with an existing enterprise system to adhere to Owner standards already in-place and to achieve integration.

2. Owner's control system integrator will provide the following services:

a. Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.

b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.

c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.

3. Engage Owner's control system integrator to provide the following services:

a. Enterprise system expansion and development of graphics, logs, reports, trends and other operational capabilities of enterprise system for I/O being added to DDC control system for use by enterprise system operators.

b. Limited assistance during commissioning to extent of DDC system integration with existing enterprise system.

c. Prepare on-site demonstration mockup of integration of DDC system to be installed with existing system before installing DDC system.

4. Control System Integrator Contact Information:

a. Company: Controls Management Inc (CMI)

5. Attend meetings with control system integrator to integrate DDC system.

3.4 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control dampers, which are specified in Section 230923.12 "DDC Control Dampers."
2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
3. Pressure sensors, which are specified in Section 230923.23 "Pressure Instruments."

3.5 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop penetrations made in fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.6 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.
1. Install gateway(s) required to suit indicated requirements.

B. Test gateway to verify that communication interface functions properly.

3.7 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.
1. Install router(s) required to suit indicated requirements.

B. Test router to verify that communication interface functions properly.

3.8 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:
1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

F. Installation of Programmable Application Controllers:
1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.9 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:
   1. Gateways.
   2. Routers.
   3. Controllers.
   4. Electrical power devices.
   5. UPS units.
   6. Relays.
   7. Accessories.
   8. Instruments.
   9. Actuators
B. Attach wall-mounted enclosures to wall using the following types of steel struts:
   1. For NEMA 250, Type 1 Enclosures: Use galvanized-steel strut and hardware.
   2. For NEMA 250, Type 4 Enclosures and Enclosures Located Outdoors: Use stainless-steel strut and hardware.
   3. Install plastic caps on exposed cut edges of strut.
C. Align top or bottom of adjacent enclosures of like size.
D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using galvanized- or stainless-steel anchors.
E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.10 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.
B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.
C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.
D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.11 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install engraved phenolic nameplate with unique identification on face for each of the following:
   1. Operator workstation.
   2. Server.
   3. Printer.
   4. Gateway.
   5. Router.
   6. Protocol analyzer.
   7. DDC controller.
   8. Enclosure.
   9. Electrical power device.
   10. UPS unit.
   11. Accessory.

C. Install engraved phenolic nameplate with unique instrument identification on face of each instrument connected to a DDC controller.

D. Install engraved phenolic nameplate with identification on face of each control damper and valve actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching engraved phenolic nameplate with identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install engraved phenolic nameplate with identification on face of access door directly below.

G. Warning Labels:
   1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
   2. Shall be located in highly visible location near power service entry points.

3.12 NETWORK INSTALLATION

A. Install fiber-optic cable when connecting between the following network devices and when located in different buildings on campus, or when distance between devices exceeds 250 feet:
   1. Operator workstations.
   2. Operator workstations and network controllers.
   3. Network controllers.

B. Install copper or fiber-optic cable when connecting between the following network devices located in same building:
   1. Operator workstations.
   2. Operator workstations and network controllers.
   3. Network controllers.

C. Install copper cable when connecting between the following:
   1. Gateways.
   2. Gateways and network controllers or programmable application controllers.
   3. Routers.
   4. Routers and network controllers or programmable application controllers.
   5. Network controllers and programmable application controllers.
   6. Programmable application controllers.
   7. Programmable application controllers and application-specific controllers.
   8. Application-specific controllers.

D. Install network cable in continuous raceway.
   1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.13 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:
   1. MAC Address:
      a. Every network device shall have an assigned and documented MAC address unique to its network.
      b. Ethernet Networks: Document MAC address assigned at its creation.
      c. ARCNET or MS/TP networks: Assign from 00 to 64.
   2. Network Numbering:
      a. Assign unique numbers to each new network.
      b. Provide ability for changing network number through device switches or operator interface.
      c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.
   3. Device Object Identifier Property Number:
      a. Assign unique device object identifier property numbers or device instances for each device network.

b. Provide for future modification of device instance number by device switches or operator interface.

c. LAN shall support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

a. Device object name property field shall support 32 minimum printable characters.

b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."

2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:

a. Object name property field shall support 32 minimum printable characters.

b. Assign object name properties with plain-English names descriptive of application.

1) Example 1: "Zone 1 Temperature."

2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

a. Assign object identifier property numbers according to Drawings or tables indicated.

b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.14 PIPING AND TUBING INSTALLATION

A. Above-Grade Pneumatic and Air Signal Piping and Tubing Installation:

1. Material Application:

a. Install copper tubing, except as follows:

1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.

2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when concealed behind accessible ceilings and concealed in walls and connecting wall-mounted instruments with recessed connections.

B. Process Tubing Installation:

1. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:

a. Meters.

b. Sensors.
c. Switches.
d. Transmitters.

2. Support tubing according to MSS SP-69, Table 3, but at intervals no less than 60 inches.
3. Install NPS 1/2 process tubing for industrial-grade sensors, transmitters, and switches. Install stainless-steel bushings where required.
4. Make tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
5. Support tubing independent of other trades.
6. Route tubing parallel to and at right angles to building construction.
7. Install tubing concealed in areas with ceilings.
8. Install a dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.
9. Insulate process piping connected to hot water and steam systems for personnel protection if the surface temperature exceeds 120 deg F. Only insulate piping within maintenance personnel reach from floor, platform, or catwalk.
10. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F with a single wrap of PTFE tape.
11. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F with pipe compound before being made up to reduce the possibility of galling.
12. Do not make tubing connections to a fitting before completing makeup of the connection.
13. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
14. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
15. Align tubing with fitting when installed. Avoid springing tube into position.
16. Install tubing with extreme care exercised to keep foreign matter out of system. Open tubing ends shall be kept plugged to keep out dust, dirt and moisture.
17. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.
18. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within 84 inches above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

C. Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:

a. Process connection.

b. Inlet to each instrument including, sensors, transmitters, switches, gages, and other control devices.

3. Locate valves to be readily accessible from floor.

3.15 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Comply with TIA 568-C.1.

C. Wiring Method: Install cables in raceways and cable trays except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

E. Field Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

F. Conduit Installation:

1. Install conduit expansion joints where conduit runs exceed 200 feet, and conduit crosses building expansion joints.
2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
3. Maintain at least 3-inch separation where conduits run axially above or below ducts and pipes.
4. Limit above-grade conduit runs to 100 feet without pull or junction box.
5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
6. Do not fasten conduits onto the bottom side of a metal deck roof.
7. Flexible conduit is permitted only where flexibility and vibration control is required.
8. Limit flexible conduit to 3 feet long.

9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
10. Direct bury conduits underground or install in concrete-encased duct bank where indicated.
    a. Use rigid, nonmetallic, Schedule 80 PVC.
    b. Provide a burial depth according to NFPA 70, but not less than 24 inches.
11. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
12. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
13. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
14. Offset conduits where entering surface-mounted equipment.
15. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:
    a. Conduit extending from interior to exterior of building.
    b. Conduit extending into pressurized duct and equipment.
    c. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

G. Wire and Cable Installation:

1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. UTP Cable Installation:
   a. Comply with TIA 568-C.2.
   b. Do not untwist UTP cables more than 1/2 inch from the point of termination, to maintain cable geometry.
6. Installation of Cable Routed Exposed under Raised Floors:
   a. Install plenum-rated cable only.
   b. Install cabling after the flooring system has been installed in raised floor areas.
   c. Coil cable 6 feet long not less than 12 inches in diameter below each feed point.
7. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.
8. Provide strain relief.
9. Terminate wiring in a junction box.
   a. Clamp cable over jacket in junction box.
   b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
10. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
11. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
12. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
13. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
14. Wire and cable shall be continuous from terminal to terminal without splices.
15. Use insulated spade lugs for wire and cable connection to screw terminals.
16. Use shielded cable to transmitters.
17. Use shielded cable to temperature sensors.
18. Perform continuity and meager testing on wire and cable after installation.
19. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation, and replace it with new cable.

20. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
21. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
22. Protection from Electro-Magnetic Interference (EMI): Provide installation free of (EMI). As a minimum, comply with the following requirements:
    a. Comply with BICSI TDMM and TIA 569-C for separating unshielded cable from potential EMI sources, including electrical power lines and equipment.
    b. Separation between open cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
        1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
    c. Separation between cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
        1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
    d. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
        1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
        2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
        3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
    e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
    f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.16 FIBER-OPTIC CABLE SYSTEM INSTALLATION

A. Comply with TIA 568-C.3, except where requirements indicated are more stringent.
B. Raceway Installation:
    1. Install continuous raceway for routing fiber-optic cables.
    2. Install raceways continuously between pull boxes and junction boxes. Raceways shall enter and be secured to enclosures.

3. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
4. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Use long radius elbows for all fiber-optic cables.
5. Entire raceway shall be complete and raceway interior cleaned before installation of fiber-optic cables.
6. Securely fasten raceway to building structure using clamps and clips designed for purpose.
7. Install nylon or polyethylene pulling line in raceways. Clearly label as "pulling line," indicating source and destination.

C. Fiber-Optic Cable Installation:
1. Route cables as efficiently as possible, minimizing amount of cable required.
2. Continuously lubricate cables during pulling-in process.
3. Do not exceed maximum pulling tensions provided by cable manufacturer. Monitor cable pulling tension with a mechanical tension meter.
4. Arrange cables passing through pull boxes to obtain maximum clearance among cables within box.
5. As cables emerge from intermediate point pull boxes, coil cable in a figure eight pattern with loops not less than 24 inches in diameter.
6. Terminate fiber-optic cables in a fiber-optic splice organizer cabinet, unless connected equipment can accept fiber-optic cables directly. Terminate cables with connectors.
7. Install and connect appropriate opto-electronic equipment and fiber jumper cables between opto-electronic equipment and fiber-optic cable system to DDC system fiber-optic cable system. Verify interface compatibility.

D. Cable and Raceway Identification:
1. Label cables at both ends. Labels shall be typed, not handwritten.
2. Mark raceways at each pull box indicating the type and number of cables within.

3.17 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.
B. Check instruments for proper location and accessibility.
C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. Control Damper Checkout:
1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

F. Instrument Checkout:
1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:
a. Verify sensing element type and proper material.
b. Verify length and insertion.

3.18 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

N. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

O. Switches: Calibrate switches to make or break contact at set points indicated.

P. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.19 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.20 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
   a. Upper quarter of range.
   b. Lower quarter of range.
   c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.21 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.
5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 20 business days before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.
   a. Verify analog I/O points at operating value.
   b. Make adjustments to out-of-tolerance I/O points.
      1) Identify I/O points for future reference.
      2) Simulate abnormal conditions to demonstrate proper function of safety devices.
      3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:
   a. Re-check I/O points that required corrections during initial test.
   b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
5. After 24 Hours of Second Validation Test:
   a. Re-check I/O points that required corrections during second test.
   b. Continue validation testing until I/O point is normal on two consecutive tests.
6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.

7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate HLC.
   a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and 50 percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.
2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:
   a. Reaction to COV and alarm conditions during HLC.
   b. Ability to update DDC system database during HLC.
5. Passing test is contingent on the following:
   a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of HLC.
   b. All alarms, both binary and analog, are reported and printed; none are lost.
   c. Compliance with response times specified.
6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.22 DDC SYSTEM WIRELESS NETWORK VERIFICATION

A. DDC system Installer shall design wireless DDC system networks to comply with performance requirements indicated.

B. Installer shall verify wireless network performance through field testing and shall document results in a field test report.

C. Testing and verification of all wireless devices shall include, but not be limited to, the following:

1. Speed.
2. Online status.

3. Signal strength.

3.23 FINAL REVIEW

A. Submit written request to Architect and Engineer when DDC system is ready for final review. Written request shall state the following:
   1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
   2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
   3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
   4. DDC system is complete and ready for final review.

B. Review by Architect and Engineer shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals and begin procedures indicated in "Extended Operation Test" Article when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.
   1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
   2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
   3. Demonstration shall include, but not be limited to, the following:
      a. Accuracy and calibration of 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.

b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.

c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.

d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.

e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.

f. Trends, summaries, logs and reports set-up for Project.

g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.

h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.

i. Software's ability to edit control programs off-line.

j. Data entry to show Project-specific customizing capability including parameter changes.

k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.

l. Execution of digital and analog commands in graphic mode.

m. Spreadsheet and curve plot software and its integration with database.

n. Online user guide and help functions.

o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.

p. System speed of response compared to requirements indicated.

q. For Each Network and Programmable Application Controller:

1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.

2) Operator Interface: Ability to connect directly to each type of digital controller with a portable operator workstation and PDA. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.

3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.

4) Electric Power: Ability to disconnect any controller safely from its power source.

5) Wiring Labels: Match control drawings.

6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.

7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

r. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.

2) Graphics are complete.

3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.

2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.

3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated.

4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.

5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.

6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.

7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.

8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.

9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.

10) Device and Network Management:

a) Display of network device status.

b) Display of BACnet Object Information.

c) Silencing devices transmitting erroneous data.

d) Time synchronization.

e) Remote device re-initialization.

f) Backup and restore network device programming and master database(s).

g) Configuration management of routers.

3.24 EXTENDED OPERATION TEST

A. Extended operation test is intended to simulate normal operation of DDC system by Owner.

B. Operate DDC system for an operating period of 14 consecutive calendar days following Substantial Completion. Coordinate exact start date of testing with Owner.

C. Provide an operator familiar with DDC system installed to man an operator workstation while on-site during normal business days occurring during operating period.

D. During operating period, DDC system shall demonstrate correct operation and accuracy of monitored and controlled points as well as operation capabilities of sequences, logs, trends, reports, specialized control algorithms, diagnostics, and other software indicated.

1. Correct defects of hardware and software when it occurs.

E. Definition of Failures and Downtime during Operating Period:

1. Failed I/O point constituting downtime is an I/O point failing to perform its intended function consistently and a point physically failed due to hardware and software.

2. Downtime is when any I/O point in DDC system is unable to fulfill its' required function.

3. Downtime shall be calculated as elapsed time between a detected point failure as confirmed by an operator and time point is restored to service.

4. Maximum time interval allowed between DDC system detection of failure occurrence and operator confirmation shall be 0.5 hours.
5. Downtime shall be logged in hours to nearest 0.1 hour.
6. Power outages shall not count as downtime, but shall suspend test hours unless systems are provided with UPS and served through a backup power source.
7. Hardware or software failures caused by power outages shall count as downtime.

F. During operating period, log downtime and operational problems are encountered.
1. Identify source of problem.
2. Provide written description of corrective action taken.
3. Record duration of downtime.
4. Maintain log showing the following:
a. Time of occurrence.
b. Description of each occurrence and pertinent written comments for reviewer to understand scope and extent of occurrence.
c. Downtime for each failed I/O point.
d. Running total of downtime and total time of I/O point after each problem has been restored.
5. Log shall be available to Owner for review at any time.

G. For DDC system to pass extended operation test, total downtime shall not exceed 1 percent of total point-hours during operating period.
1. Failure to comply with minimum requirements of passing at end of operating period indicated shall require that operating period be extended one consecutive day at a time until DDC system passes requirement.

H. Evaluation of DDC system passing test shall be based on the following calculation:
1. Downtime shall be counted on a point-hour basis where total number of DDC system point-hours is equal to total number of I/O points in DDC system multiplied by total number of hours during operating period.
2. One point-hour of downtime is one I/O point down for one hour. Three points down for five hours is a total of 15 point-hours of downtime. Four points down for one-half hour is 2 point-hours of downtime.
3. Example Calculation: Maximum allowable downtime for 30-day test when DDC system has 1000 total I/O points (combined analog and binary) and has passing score of 1 percent downtime is computed by 30 days x 24 h/day x 1000 points x 1 percent equals 7200 point-hours of maximum allowable downtime.

I. Prepare test and inspection reports.

3.25 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.26 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by DDC system manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.27 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year(s).

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two year(s) from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.28 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:
   a. Provide not less than 2 days of training total.
   b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
   c. Total days of training shall be broken into not more than four separate training classes.

d. Each training class shall be not less than 1/2 day.

4. Schedule training with Owner 5 business days before expected Substantial Completion.
5. Schedule training to provide Owner with at least 10 business days of notice in advance of training.
6. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 15-minute break between sessions. Morning and afternoon sessions shall be separated by 60-minute lunch period. Training, including breaks and excluding lunch period, shall not exceed eight hours per day.
7. Provide staggered training schedules as requested by Owner

C. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

D. Training Attendee Headcount:

1. Plan in advance of training for five attendees.
2. Make allowance for Owner to add up to one attendee(s) at time of training.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

E. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.

3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

F. Instructor Requirements:
1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

G. Organization of Training Sessions:
1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
a. Daily operators.
b. Advanced operators.
c. System managers and administrators.
2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

H. On-Site Training:
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

I. Training Content for Daily Operators:
1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.

4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
    a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.

b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.

c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.

d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.

e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.

f. Each control loop responds to set point adjustment and stabilizes within time period indicated.

g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

J. Training Content for Advanced Operators:

1. Making and changing workstation graphics.
2. Creating, deleting and modifying alarms including annunciation and routing.
3. Creating, deleting and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting and modifying reports.
5. Creating, deleting and modifying points.
6. Creating, deleting and modifying programming including ability to edit control programs off-line.
7. Creating, deleting and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing and repairing hardware.
15. Adjusting, calibrating and replacing DDC system components.

K. Training Content for System Managers and Administrators:
   1. DDC system software maintenance and backups.
   2. Uploading, downloading and off-line archiving of all DDC system software and databases.
   3. Interface with Project-specific, third-party operator software.
   4. Understanding password and security procedures.
   5. Adding new operators and making modifications to existing operators.
   6. Operator password assignments and modification.
   7. Operator authority assignment and modification.
   8. Workstation data segregation and modification.

L. Video of Training Sessions:
   1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
   2. Stamp each recording file with training session number, session name and date.
   3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
   4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 230923

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SECTION 230923.12

CONTROL DAMPERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes the following types of control dampers and actuators for the control systems:

1. Rectangular control dampers.
2. Round control dampers.
3. General control-damper actuator requirements.
4. Electric and electronic actuators.

1.3 DEFINITIONS

A. DDC: Direct-digital control.

B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.

5. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control dampers and actuators, including the following.
   a. Flow at project design and minimum flow conditions.
   b. Face velocity at project design and minimum airflow conditions.
   c. Pressure drop across damper at project design and minimum airflow conditions.
   d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
   e. Maximum close-off pressure.
   f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
   g. Torque required at worst case condition for sizing actuator.
   h. Actuator selection indicating torque provided.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and co

B. rresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to room, duct, and equipment.
2. Size and location of wall access panels for control dampers and actuators installed behind walls.
3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.

F. Environmental Conditions:

1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
   a. Hazardous Locations: Explosion-proof rating for condition.

G. Selection Criteria:

1. Control dampers shall be suitable for operation at following conditions:
   a. Supply Air: 6” wc static pressure and 30˚ to 100˚ F.
   b. Return Air: 6” wc static pressure and 30˚ to 100˚ F
   c. Outdoor Air: 3” wc static pressure and -15˚ to 125˚ F
   d. Mixed Air: 6” wc static pressure and 30˚ to 100˚ F.
   e. Exhaust Air: 6” wc static pressure and 30˚ to 100˚ F.
2. Fail positions unless otherwise indicated:
   a. Supply Air: Open.
   b. Return Air: Open.
   c. Outdoor Air: Close.
   d. Mixed Air: Open.
   e. Exhaust Air: Close.
3. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
4. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.
5. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

3. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Greenheck.
   b. Nailor.
   c. Pottorff.
   d. Ruskin Company.
2. Performance:
   a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
   b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
   c. Velocity: Up to 6000 fpm.
   d. Temperature: Minus 40 to plus 185 deg F.
   e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
   f. Damper shall have AMCA seal for both air leakage and air performance.
3. Construction:
   a. Frame:
      1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
      2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch).
      3) Width not less than 5 inches.
   b. Blades:
      1) Hollow, airfoil, extruded aluminum.
      2) Parallel or opposed blade configuration as required by application.
      3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
      4) Width not to exceed 6 inches.
      5) Length as required by close-off pressure, not to exceed 48 inches.
   c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- diameter stainless steel, mechanically attached to blades.

e. Bearings:
1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:
1) Concealed in frame.
2) Constructed of aluminum or stainless steel.
3) Hardware: Stainless steel.

g. Transition:
1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches.
4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:
1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

2.3 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Greenheck.
b. Nailor.
c. Pottorff.
d. Ruskin Company.

2. Performance:

a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.
d. Temperature: Minus 25 to plus 200 deg F.
e. Pressure Rating: 8-in. wg for sizes through 12 inches, 6-in. wg for larger sizes.

3. Construction:
a. Frame:
1) Material: Galvanized or stainless steel, 0.04 in thick.
2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
3) Sleeve-type connection for mating to adjacent ductwork.
4) Size Range: 4 to 24 inches.
5) Length not less than 7 inches.
6) Provide 2-inch sheet metal stand-off for mounting actuator.
b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized or stainless steel.
c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
d. Axle: 0.5-inch- diameter stainless steel, mechanically attached to blade.
e. Bearings: Stainless-steel sleeve pressed into frame.

B. Round Dampers, Flanged Type:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Greenheck.
b. Nailor.
c. Pottorff.
d. Ruskin Company.
2. Performance:
a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
b. Pressure Drop: 0.03-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 4000 fpm.

d. Temperature: Minus 25 to plus 250 deg F.

e. Pressure Rating: 8-in. wg for sizes through 36 inches in diameter, 6-in. wg for larger sizes.

3. Construction:

a. Frame:

1) Size Range: 4 to 60 inches.

2) Material: Galvanized or stainless steel.

a) Sizes through 24 Inches in Diameter: 0.15 inch thick.

b) Sizes 26 through 48 Inches in Diameter: 0.25 inch thick.

c) Larger Sizes: 0.31 inch thick.

3) Flanges:

a) Outward rolled with bolt holes on each end of frame for mating to adjacent ductwork.

b) Face: Not less than 1.25 inch for damper sizes through 12 inches in diameter, 1.5 inch for damper sizes 14 through 24 inches in diameter, and 2 inches for larger sizes.

4) Length (Flange Face to Face): Not less than 8 inches.

5) Provide 3-inch sheet metal stand-off for mounting actuator.

b. Blade: Reinforced circular flat blade constructed of galvanized or stainless steel.

1) Sizes through 24 Inches: 0.15 inch thick.

2) Sizes 26 through 48 Inches: 0.19 inch thick.

3) Larger Sizes: 0.25 inch thick.

c. Blade Stop: Full circumference, located in airstream, minimum 0.5 by 0.25 inch galvanized- or stainless- steel bar.

d. Blade Seal: Neoprene, mechanically attached to blade and fully encompassing blade edge.

e. Axle: Plated or stainless steel, mechanically attached to blade.

1) Sizes through 14 Inches: 0.5 inch in diameter.

2) Sizes 16 through 42 Inches: 0.75 inch in diameter.

3) Larger Sizes: 1 inch in diameter.

f. Bearings: Stainless-steel sleeve pressed into frame.

2.4 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions: As indicated below:

1. Exhaust Air: Close.
2. Outdoor Air: Close.
3. Supply Air: Open.
4. Return Air: Open.

2.5 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:

1. 24 V.
2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:

1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
2. Control Input Signal:
   a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
   b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for 2- to 10-V dc and 4- to 20-mA signals.
   c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.
   d. Programmable Multi-Function:
      1) Control input, position feedback, and running time shall be factory or field programmable.
      2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
      3) Service data, including at a minimum, number of hours powered and number of hours in motion.

G. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

H. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

I. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

J. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

K. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

L. Stroke Time:

1. Move damper to failed position within 30 seconds.
2. Select operating speed to be compatible with equipment and system operation.
3. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

M. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:

B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
   1. Rectangular Air Duct Applications: Rectangular dampers with aluminum airfoil blades.
   2. Round Air Duct Applications: Round dampers, flange type.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:
   1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
   2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
   3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:
   1. Use products that are suitable for environment to which they will be subjected.
   2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
      a. Laboratory exhaust airstreams.
      b. Process exhaust airstreams.
   3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
   4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.

2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.

2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.6 CONNECTIONS

A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with damper identification on damper and on face of ceiling where damper is concealed above ceiling.

3.8 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic dampers, verify that pressure gages are provided in each airline to damper actuator and positioner.
6. Verify that control dampers are installed correctly for flow direction.
7. Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Verify that damper frame attachment is properly secured and sealed.
9. Verify that damper actuator and linkage attachment are secure.
10. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
11. Verify that damper blade travel is unobstructed.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

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SECTION 230923.14

FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Airflow sensors.
2. Airflow transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. Ethernet: Local area network based on IEEE 802.3 standards.

B. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

C. PEEK: polyetheretherketone.

D. PTFE: Polytetrafluoroethylene.

E. PPS: Polyphenylene sulfide.

F. RS-485: A TIA standard for multipoint communications using two twisted pairs.

G. RTD: Resistance temperature detector.

H. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power

requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include diagrams for air and process signal tubing.
5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Delegated-Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.
   a. Flow at Project design and minimum flow conditions.
   b. Pressure drop at Project design and minimum flow conditions.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during one-year period following warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

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

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of 10 percent above Project design flow and 10 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

2.3 AIRFLOW SENSORS:

A. Performance Requirements:
   1. Adjustable for changes in system operational parameters.
   2. Airflow Sensor and Transmitter Range: Extended range of 10percent above Project design flow and 10percent below minimum Project flow to signal abnormal flow conditions.
   3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
      a. Product certificates are required.

B. Piezometer Ring Fan Inlet Airflow Sensor:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Ebtron.
      b. Twin City Fan & Blower.
   2. In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of air volume flow rate.
   3. Multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
   4. Sensor points shall not protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.
   5. Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
   6. Sensor shall be non-intrusive and not impact fan performance.
   7. Product shall be a standard offering of the fan manufacturer and include published literature with supporting test data to validate sensor performance.

C. Thermal Airflow Station:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
      a. Ebtron, Inc.

2. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.
3. Description: Airflow station shall consist of one or more sensor probes mounted in a casing, and a remotely mounted microprocessor-based transmitter.
4. Performance:
   a. Capable of independently processing up to 16 independently wired sensor assemblies.
   b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
   c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
   d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
   e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
   f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and three temperatures to standards that are traceable to NIST.
   g. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range.
      1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.
   h. Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.
   i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.
   j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
   k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
   l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
   m. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
   n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 1 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with

submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.

5. Sensor Assemblies:
   a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
   b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
   c. Thermistor leads shall be protected and not exposed to the environment.
   d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
   e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
   f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.
   g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.
6. Casing:
   a. Factory mount sensor probes in an airflow station casing to create a single assembly for field mounting.
   b. Material: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.
   c. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with zinc-rich paint.
   d. Casing Depth: At least 8 inches.
   e. Include casing inlet and discharge connections with a minimum1.5-inch face flange.
7. Transmitter:
   a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
   b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
      1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
         a) Integral protection from transients and power surges.

b) Circuitry to ensure reset after power disruption, transients, and brownouts.

c) Integral transformer to convert field power source to operating voltage required by instrument.

c. Remote Signal Interface:

1) Linear Analog Signals for Airflow and Temperature: Fuse protected and isolated, 4 to 20 mA.

2) RS-485: BACnet-ARCNET, BACnet-MS/TP, and Modbus-RTU.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Provide the services of an independent inspection agency to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.

2. Do not begin installation without submittal approval of mounting location.

E. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

F. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Duct-Mounted Airflow Sensors:

1. Thermal airflow station.

C. Damper-Mounted Airflow Sensors:

1. Thermal airflow station.

D. Fan-Mounted Airflow Sensors:

1. Piezometer ring fan inlet airflow sensor.

3.3 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted l

F. adder placement is possible under occupied condition.

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Mounting Height:
1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
   a. Make every effort to mount at 60 inches.

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.6 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:
1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

3.7 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.8 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.9 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an

installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:
1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

C. Digital Signals:
1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

END OF SECTION 230923.14

SECTION 230923.22

POSITION INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes position limit switches for use in direct-digital control systems for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.22.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include operating characteristics, electrical characteristics, and furnished accessories indicating default control signal with loss of power and electrical power requirements.
2. Include product description with complete technical data and product specification sheets.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring.

PART 2 - PRODUCTS

2.1 POSITION LIMIT SWITCHES

A. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.

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

B. Performance:

1. Life expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.
2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.

3. Voltage: 125-, 250-, 480-, and 600-V ac or 8-, 12-, 14-, 24-, 30-, 48-, 125-, and 250-V dc, as required by application.
4. Current Rating: As required by application.
5. Temperature Rise: 50 deg C.
6. Ambient Temperature: 14 to 175 deg F.
7. Ambient Relative Humidity: 35 to 95 percent.

C. Construction:

1. NEMA 250, Type 4X enclosure.
2. Switch Type: SPDT or DPDT, as required by application.
3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
4. Electrical Connection: Screw or plug-in terminals.
5. Conduit Connection: NPS 1/2.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to:
    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 POSITION INSTRUMENTS INSTALLATION

A. Mounting Location:
1. Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
2. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 ADJUSTMENT, CALIBRATION, AND TESTING

A. Digital Signals:
1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

B. Switches: Calibrate switches to make or break contact at set points indicated.

END OF SECTION 230923.22

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SECTION 230923.23

PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 DEFINITIONS

A. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a control, asset management, safety, or other system using any control platform.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics; electrical characteristics; and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space, showing relationship to light switches, fire alarm devices, and other installed devices.
3. Size and location of wall access panels for instruments installed behind walls.
4. Size and location of ceiling access panels for instruments installed in accessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Product Test Reports: For each product requiring test performed by a qualified testing agency.

D. Source quality-control reports.

E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:
1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
a. If instrument alone cannot comply with requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.
2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in

protective secondary enclosures. Instrument-installed location shall dictate following NEMA 250 enclosure requirements:

a. Outdoors, Protected: Type 3.
b. Outdoors, Unprotected: Type 4X.
c. Indoors, Heated with Filtered Ventilation: Type 1.
d. Indoors, Heated with Nonfiltered Ventilation: Type 12.
e. Indoors, Heated and Air-Conditioned: Type 1.
f. Mechanical Equipment Rooms:
    1) Chiller and Boiler Rooms: Type 12.
    2) Air-Moving Equipment Rooms: Type 1.
g. Localized Areas Exposed to Washdown: Type 4X.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 3.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4X.
j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:
1. Insertion length shall be at 6 inches.
2. Sensor with four radial holes of 0.04-inch diameter.
3. Stainless-steel construction.
4. Sensor with threaded end support, sealing washers and nuts.
5. Connection: NPS 1/4 compression fitting.
6. Suitable for flat oval, rectangular, and round duct configurations.

B. Duct Insertion Static Pressure Sensor:
1. Sensor probe with two opposing orifices designed to reduce error-associated air velocity.
2. Sensor insertion length shall be 8 inches.
3. Construct sensor of 6061-T6 aluminum alloy or Type 304 stainless steel.
4. Connection: Threaded, NPS 1/8 swivel fitting for connection to copper tubing or NPS 1/4 barbed fitting for connection to polyethylene tubing.
5. Sensor probe attached to a mounting flange with neoprene gasket and two holes for fasteners.
6. Mounting flange shall suitable for flat oval, rectangular, and round duct configurations.
7. Pressure Rating: 10 psig.

C. Duct Traverse Static Pressure Sensor:

1. Sensor shall traverse the duct cross section and have at least one pickup point every 6 inches along length of sensor.
2. Construct sensor of 18-gage Type T6063-T5 extruded and anodized aluminum.
3. Sensor supported with threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at other end.
4. Mounting plate with threaded, NPS 3/8 compression fitting for connection to tubing.
5. Accuracy within 1 percent of actual operating static pressure.
6. Dual offset static sensor design shall provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30 degree yaw and pitch.
7. Suitable for velocities of 100 to 10000 fpm and temperatures of up to 200 deg F.
8. Sensor air resistance shall be less than 0.1 times the velocity pressure at probe-operating velocity.
9. Suitable for flat oval, rectangular, and round duct configurations.

D. Outdoor Static Pressure Sensor:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Setra System.
   b. Seimens
   c. Honeywell
2. Provides average outdoor pressure signal.
3. Sensor with no moving parts.
4. Kit includes sensor, vinyl tubing mounting hardware.

E. Outdoor Static Pressure Sensor:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Setra System.
   b. Seimens
   c. Honeywell
2. Provides average outdoor pressure signal.
3. Sensor with no moving parts.
4. NEMA 250, Type 4X enclosure.
5. Pressure Connection: Brass barbed fitting for NPS 1/4 tubing.
6. Conduit fitting around pressure fitting for sensor support and protection to pressure connection.

F. Outdoor Static Pressure Sensor:

1. Sensor with no moving parts.
2. Operation not affected and impaired by rain and snow.
3. Sensing plates constructed of 0.1406-inch Type 316 stainless steel.
4. Accuracy within:
   a. 1 percent of the actual outdoor atmospheric pressure when subjected to varying horizontal radial wind velocities up to 40 mph.
   b. 2 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to 40 mph with approach angles up to 30 degrees to horizontal.
   c. 3 percent of the actual outdoor atmospheric pressure while subjected to varying radial wind velocities up to 40 mph with approach angles up to 60 degrees to horizontal.
   d. Threaded, NPS 2 connection.

G. Space Static Pressure Sensor for Wall Mounting:
1. 100-micron filter mounted in stainless-steel wall plate senses static pressure.
2. Wall plate provided with gasket and screws, and sized to fit standard single-gang electrical box.
3. Back of sensor plate fitted with brass barbed fitting for tubing connection.

H. Space Static Pressure Sensor for Wall Mounting:
1. White ABS plastic wall plate with integral sensing port to sense static pressure.
2. Wall plate provided with matching colored screws and sized to fit standard single-gang electrical box.
3. Back of sensor plate fitted with brass union fitting for tubing connection.
4. Pressure rating: 10 psig.

I. Space Static Pressure Sensor for Wall Mounting:
1. Stainless-steel wall plate with perforated center arranged to sense space static pressure. Exposed surfaces are provided with brush finish.
2. Wall plate provided with screws and sized to fit standard single-gang electrical box.
3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch (3-mm) fitting for tubing connection.
4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm (5.1 m/s) from a 360-degree radial source.

J. Space Static Pressure Sensor for Recessed Ceiling Mounting:
1. Stainless-steel round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
2. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.

3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

K. Space Static Pressure Sensor for Exposed or Suspended Mounting:

1. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.
2. Stainless steel with perforations arranged to sense space static pressure. Exposed surfaces provided with brush finish.
3. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
4. Surface-mounted sensor provided with solid mounting plate intended for mount to ceiling with pressure chamber exposed to view.
5. Surface-mounted sensor with 0.125-inch fitting for exposed tubing connection.
6. Suspended sensor intended for pendent mount with pressure chamber exposed to view.
7. Suspended sensor with NPS 1/2 fitting for exposed pipe or tubing connection.

2.3 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Diaphragm operated to actuate an SPDT snap switch.
   a. Fan safety shutdown applications: Switch with manual reset.
2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
5. High and Low Process Connections: Threaded, NPS 1/8.
6. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.
7. Operating Data:
   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:
      1) Continuous: 45 inches wg.
      2) Surge: 10 psig.

c. Temperature Limits: Minus 30 to 180 deg F.

d. Operating Range: Approximately 2 times set point.

e. Repeatability: Within 3 percent.

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

B. Air-Pressure Differential Switch with Set-Point Indicator:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Setra System.
   b. Seimens
   c. Honeywell
2. Diaphragm operated to actuate an SPDT snap switch.
3. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Screw-type set-point adjustment with enclosed set-point indicator and scale.
6. High and Low Process Connections: Threaded, NPS 1/8.
7. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.
8. Operating Data:
   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:
      1) Continuous: 10 psig.
      2) Surge: 25 psig.
   c. Temperature Limits: Minus 30 to 110 deg F.
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 1 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Air-Pressure Differential Switch with Dual Scale Adjustable Set Point:

1. Diaphragm operated to actuate an SPDT snap switch.
2. Electrical Connections: Push-on screw terminals.

3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Dual scale set-point adjustment knob located inside removable enclosure cover.
5. High and Low Process Connections: Slip-on tubing connections.
6. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 13.
7. Operating Data:
   a. Electrical Rating: 1.5 A at 250-V ac.
   b. Pressure Limits: 40 inches wg.
   c. Temperature Limits: Minus 4 to 185 deg F.
   d. Operating Range: Approximately 2 times set point.

D. Air-Pressure Differential Indicating Switch:
1. Combination gage with low- and high-limit switches.
2. Nominal 4-inch- diameter analog indication with white dial face, graduated black markings, pointer to indicate measured value, and a separate adjustable pointer for each switch set point.
3. Switch zero and set-point tamperproof adjustment screws or knobs on the dial face.
4. Each switch used as a safety limit shall have a manual reset button local to switch.
5. Switch Type: Each set point shall have two Form C relays, DPDT.
6. Electrical Connections: Screw terminals.
7. Enclosure Conduit Connection: NPS 3/4 threaded connection.
8. High and Low Process Connections: Threaded, NPS 1/8.
9. Enclosure:
   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.
10. Operating Data:
   a. Electrical Rating: 10 A at 120- to 240-V ac.
   b. Pressure Limits: 25 psig.
   c. Temperature Limits: 20 to 120 deg F.
   d. Operating Range: Approximately twice normal operating range unless otherwise required for application.
   e. Accuracy:
      1) 4 percent for ranges through 0.5 in. wg.
      2) 2 percent for ranges 1 in. wg and greater.

f. Repeatability: Within 1 percent of full scale.

g. Switch Deadband: One pointer width and within 1 percent of full scale for each switch set point.

h. Power Supply: 24 or 120-V ac, 50/60 Hz.

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

2.4 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Setra System.
   b. Seimens
   c. Honeywell
2. Performance:
   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 1 percent of the full-scale range.
   c. Hysteresis: Within 0.10 percent of full scale.
   d. Repeatability: Within 0.05 percent of full scale.
   e. Stability: Within 1 percent of span per year.
   f. Overpressure: 10 psig.
   g. Temperature Limits: Zero to 150 deg F.
   h. Compensate Temperature Limits: 40 to 150 deg F.
   i. Thermal Effects: 0.033 percent of full scale per degree F.
   j. Shock and vibration shall not harm the transmitter.
3. Output Signals:
   a. Analog Current Signal:
      1) Two-wire, 4- to 20-mA dc current source.
      2) Signal capable of operating into 800-ohm load.
   b. Analog Voltage Signal:
      1) Three wire, zero to 10 V.
      2) Minimum Load Resistance: 1000 ohms.
4. Display: Four-digit digital display with minimum 0.4-inch- high numeric characters.
5. Operator Interface: Zero and span adjustments located behind cover.
6. Construction:
   a. Plastic casing with removable plastic cover.

b. Threaded, NPS 1/4 swivel fittings for connection to copper tubing or NPS 3/16 barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.

c. Screw terminal block for wire connections.

d. Vertical plane mounting.

e. NEMA 250, Type 4.

f. Provide mounting bracket suitable for installation.

B. Air Pressure Differential Transmitter:

1. Performance:

a. Range: Approximately 2 times set point.

b. Accuracy: Within 0.5 percent of the span at reference temperature of 70 deg F.

c. Hysteresis: Within 0.02 percent of the span.

d. Repeatability: Within 0.05 percent of the calibrated span.

e. Stability: Within 0.25 percent of span per year.

f. Overpressure: 15 psig.

g. Temperature Limits: Minus 20 to 160 deg F.

h. Compensate Temperature Limits: 35 to 135 deg F.

i. Thermal Effects: 0.015 percent of full scale per degree F.

j. Warm-up Time: Within 5 seconds.

k. Response Time: 250 ms.

l. Shock and vibration shall not harm the transmitter.

2. Output Signals:

a. Analog Current Signal:

1) Two-wire, 4- to 20-mA dc current source.

2) Signal capable of operating into 1000-ohm load.

b. Analog Voltage Signal:

1) Three wire, zero to 6 V.

2) Minimum Load Resistance: 1000 ohms.

3. Operator Interface:

a. Zero and span adjustments within 10 percent of full span.

b. Potentiometer adjustments located on face of transmitter.

4. Construction:

a. Type 300 stainless-steel enclosure.

b. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.

c. Screw terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 2.
f. Mounting Bracket: Appropriate for installation.
g. Reverse wiring protected.
h. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

C. Air-Pressure Differential Transmitters for Hazardous Environments:
1. FM Approved for hazardous environments. Intrinsically safe for Classes I, II, and III, Divisions 1 and 2, Groups A through H.
2. Performance:
a. Range: Approximately 2 times set point.
b. Accuracy: Within 0.5 percent of the span at reference temperature of 70 degrees F.
c. Hysteresis: Within 0.02 percent of the span.
d. Repeatability: Within 0.05 percent of the calibrated span.
e. Stability: Within 0.25 percent of span per year.
f. Overpressure: 20 psig.
g. Temperature Limits: Minus 20 to 185 deg F.
h. Compensate Temperature Limits: Zero to 160 deg F.
i. Thermal Effects: 0.01 percent of full scale per degree F.
j. Warm-up Time: Within 5 seconds.
k. Response Time: 250 ms.
l. Shock and vibration shall not harm the transmitter.
3. Output Signals:
a. Analog Current Signal:
1) Two-wire, 4- to 20-mA dc current source.
2) Signal capable of operating into 1000-ohm load.
b. Analog Voltage Signal:
1) Three wire, zero to 6 V.
2) Minimum Load Resistance: 1000 ohms.
4. Operator Interface:
a. Zero and span adjustments within 10 percent of full span.
b. Potentiometer adjustments located on face of transmitter.
5. Construction:

a. Type 300 stainless-steel enclosure.
b. Swivel fittings for connection to tubing. Fittings on bottom of instrument enclosure.
c. Two 1/2-inch trade size conduit connections isolated from electronics.
d. Screw terminal block for wire connections.
e. Vertical plane mounting.
f. NEMA 250, Type 4X.
g. Mounting Bracket: Appropriate for installation.

6. Reverse wiring protected.
7. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

D. Air-Pressure Differential Indicating Transmitter:

1. Performance:
   a. Range: Approximately 2 times set point.
   b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at 77 deg F.
   c. Stability: Within 1 percent of full scale per year.
   d. Overpressure: 10 psig.
   e. Temperature Limits: 20 to 120 deg F.
   f. Thermal Effects: 0.055 percent of full scale per degree F.
2. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
3. Operator Interface:
   a. Zero and span adjustments.
   b. Selectable engineering units.
4. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into a 1200-ohm load.
5. Construction:
   a. Plastic casing with clear plastic cover.
   b. Integral fittings for plastic tubing connections on side of instrument case for high- and low-pressure connections.
   c. Terminal block for wire connections.
   d. Vertical plane mounting.
   e. NEMA 250, Type 1.
   f. Nominal 4-inch diameter face.
   g. Mounting Bracket: Appropriate for installation.

E. Air-Pressure Differential Indicating Transmitter:
1. Performance:
a. Range: Approximately 2 times set point.
b. Accuracy including hysteresis and repeatability: Within 0.25 percent of full scale.
c. Stability: Within 1 percent of full scale per year.
d. Overpressure: Varies with range. At least 1.5 times range.
e. Temperature Limits: Zeroto 140 deg F.
f. Compensate Temperature Limits: 20 to 120 deg F.
g. Thermal Effects: 0.02 percent of full scale per degree F.
2. Display: Digital with minimum 0.4-inch- high numeric characters.
3. Operator Interface: Zero and span adjustments.
4. Analog Output Current Signal:
a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into a 1200-ohm load.
5. Construction:
a. Plastic casing with removable clear plastic cover.
b. Integral barbed fittings for rubber or plastic tubing connections on bottom of instrument case for high- and low-pressure connections.
c. Screw terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 4X.
f. Mounting Bracket: Appropriate for installation.

F. Air-Pressure Differential Indicating Transmitter with Field-Selectable Features:
1. Field-Selectable Features:
a. Field configurable for pressure and velocity applications through user interface.
b. Field selectable from one of three pressure ranges both in SI (metric) and inch-pound (IP) units of measure.
c. Select range based on application. Range shall be approximately 2 times set point.
2. Performance:
a. Accuracy Including Hysteresis and Repeatability:
1) Within 2 percent for 0.10 in. wg, 1.0 in. wg and all bi-directional ranges.
2) Within 1 percent for other ranges.
b. Stability: Within 1 percent of full scale per year.
c. Response Time: Adjustable 0.5- to 15-second time constant with 95 percent response within 1.5 to 45 seconds.

d. Overpressure: 1 psig maximum operating; 10 psig burst pressure.
e. Temperature Limits: Zero to 150 deg F.

3. Display: Four-digit digital display with minimum 0.4-inch- high numeric characters.
4. Operator Interface:
   a. Selectable pressure ranges, where indicated.
   b. Zero and span adjustments.
   c. Selectable air velocity mode with square root function.
   d. Adjustable signal dampening
5. Analog Output Current Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into a 1200-ohm load.
6. Analog Output Voltage Signal:
   a. Three wire, zero to 10 V.
   b. Minimum Load Resistance: 1000 ohms.
7. Construction:
   a. Plastic casing with removable clear plastic cover.
   b. NPS 3/16 nominal ID plastic tubing connections on side of instrument case for high- and low-pressure connections.
   c. NPS 1/2 NPS threaded connection for conduit.
   d. Terminal block for wire connections.
   e. Vertical plane mounting.
   f. NEMA 250, Type 4X.
   g. Nominal 4-inch- diameter face.
   h. Mounting Bracket: Appropriate for installation.

G. Air-Pressure Differential Transmitter with 0.10 Percent Accuracy and Auto Zero Feature:
1. Description:
   a. 4- to 20-mA dc output signal.
   b. NEMA 250, Type 1 enclosure.
   c. Construct the assembly so that shock, vibration, and pressure surges of up to 1 psig will neither harm nor affect the accuracy of the transmitter.
   d. Transmitter with automatic zeroing circuit capable of automatically readjusting the transmitter to zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.
   e. Performance:
      1) Range: Approximately 2 times set point.

2) Calibrated Span: Field adjustable, minus 40 percent of the range.
3) Accuracy: Within 0.10 percent of natural span.
4) Repeatability: Within 0.15 percent of calibrated span.
5) Linearity: Within 0.2 percent of calibrated span.
6) Hysteresis and deadband (combined): Less than 0.2 percent of calibrated span.

f. Integral digital display for continuous indication of pressure differential.

H. Air-Pressure Differential Transmitter with 0.25 Percent Accuracy and Auto Zero Feature:

1. Description:
a. 4- to 20-mA dc output signal.
b. NEMA 250, Type 1 enclosure.
c. Construct assembly so shock, vibration, and pressure surges of up to 1 psig will neither harm nor affect the accuracy of the transmitter.
d. Transmitter with automatic zeroing circuit capable of automatically readjusting the transmitter to zero at predetermined time intervals. The automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.
e. Performance:
1) Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
2) Calibrated Span: Field adjustable, minus 40 percent of the range.
3) Accuracy: Within 0.25 percent of natural span.
4) Repeatability: Within 0.15 percent of calibrated span.
5) Linearity: Within 0.2 percent of calibrated span.
6) Hysteresis and deadband (combined): Less than 0.2 percent of calibrated span.
f. Integral digital display for continuous indication of pressure differential.

I. Air-Pressure Differential Indicating Transmitter, Switch, and Controller:

1. Description:
a. Three-in-one instrument, including digital display, control relay switches, and a transmitter with a current output.
b. Field configurable for pressure, velocity, and volumetric flow applications through user interface.
c. Select instrument range based on application. Range shall be approximately 2 times set point.
2. Performance:

a. Accuracy Including Hysteresis and Repeatability:
   1) Within 1 percent for ranges less than 5 in. wg.
   2) Within 0.5 percent at 77 deg F for other ranges.
b. Stability: Within 1 percent per year.
c. Response Time: 250 ms.
d. Overpressure: 5 psig for instrument ranges less than 50 in wg and 9 psig for 100 in. wg range.
e. Temperature Limits: 32 to 140 deg F.
f. Thermal Effects: 0.020 percent per degree F.
g. Warm-up Period: One hour.

3. Controller Programming through Menu Keys to Access Five Menus:
   a. Security level.
   b. Pressure, velocity, or flow application.
   c. Engineering units.
   d. K-factor for use with flow application.
   e. Set-point control only; set-point and alarm operation; and alarm operation as high, low, or high/low with manual or automatic reset and delay.
   f. View high and low readings.
   g. Digital dampening for smoothing erratic applications.
   h. Scaling of analog output to fit range and field calibration.
4. Display:
   a. Digital, four-digit display with backlight, with 0.4-inch- high alphanumeric characters.
   b. Four indicators; two for set point and two for alarm status.
5. Operator Interface:
   a. Set-point adjustment through keypad on face of instrument.
   b. Zero and span adjustments accessible through menu.
   c. Programming through keypad.
6. Analog Output Signal:
   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into a 900-ohm load.
7. Digital Output Signal:
   a. Two SPDT relays.
   b. Each rated for one amp at 30-V ac or dc.
8. Construction:

a. Die cast-aluminum casing and bezel.
b. Threaded, NPS 1/8 connections on side and back.
c. Vertical plane mounting.
d. NEMA 250, Type 1.
e. Nominal 4-inch- diameter face.
f. Mounting Bracket: Appropriate for installation.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled pressure instruments, as indicated by instrument requirements. Affix standards organization's certification and label.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

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

3.2 PRESSURE INSTRUMENT APPLICATIONS

A. Duct-Mounted Static Pressure Sensors:
1. System: Duct insertion static pressure sensor.

B. Space Static Pressure Sensors:
1. System: Space static pressure sensor for exposed or suspended mounting.

C. Air-Pressure Differential Switches:
1. System: Air-pressure differential switch with set-point indicator.

D. Air-Pressure Differential Transmitters:
1. Duct System: Air-pressure differential transmitter.
2. Space System: Air-pressure differential transmitter.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

2. Install switches and transmitters for air pressure associated with individual air-handling units and associated connected ductwork near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:
1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 67percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:
1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.

7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.7 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
4. Equipment and procedures used for calibration shall comply with instrument manufacturer's recommendations.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:
1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:
1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of project design values.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include

quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.23

SECTION 230923.27

TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Combination air temperature sensors and switches.
3. Air temperature switches.
4. Air temperature RTD transmitters.

1.3 DEFINITIONS

A. HART (Highway Addressable Remote Transducer) Protocol: The global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bidirectional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from a technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.

B. RTD: Resistance temperature detector.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation operation and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

C. Samples: For each exposed product installed in finished space.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Product installation location shown in relationship to room, duct, pipe, and equipment.
2. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
3. Sizes and locations of wall access panels for instruments installed behind walls.
4. Sizes and locations of ceiling access panels for instruments installed in inaccessible ceilings.

B. Product Certificates: For each product requiring a certificate.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:
1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.
2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:
a. Outdoors, Protected: Type 3.

b. Outdoors, Unprotected: Type 4X.
c. Indoors, Heated with Filtered Ventilation: Type 1.
d. Indoors, Heated with Non-Filtered Ventilation: Type 12.
e. Indoors, Heated and Air Conditioned: Type 1.
f. Localized Areas Exposed to Washdown: Type 4X.
g. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: Type 2.
h. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4.
i. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:
1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
a. Range: Minus 50 to 275 deg F.
b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
c. Repeatability: Within 0.5 deg F.
d. Self-Heating: Negligible.
4. Transmitter Requirements:
a. Transmitter required for each 100-ohm RTD.
b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
a. HONEYWELL.
b. JOHNSON CONTROLS.
c. SIEMENS.
2. 100 or 1000 ohms.
3. Temperature Range: Minus 50 to 275 deg F.
4. Probe: Single-point sensor with a stainless-steel sheath.
5. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.

6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch trade size.

C. Platinum RTD, Air Temperature Averaging Sensors:
1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F.
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch trade size.

D. Platinum RTD Outdoor Air Temperature Sensors:
1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F.
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:
1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 212 deg F.
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. HONEYWELL.
   b. JOHNSON CONTROLS.
   c. SIEMENS.
2. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
3. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
4. Performance Characteristics:
   a. Range: Minus 50 to 275 deg F.
   b. Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
   c. Repeatability: Within 0.5 deg F.
   d. Drift: Within 0.5 deg F over 10 years.
   e. Self-Heating: Negligible.
5. Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:
1. Temperature Range: Minus 50 to 275 deg F.
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches long.
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2- inch trade size.

H. Thermistor Averaging Air Temperature Sensors:
1. Temperature Range: Minus 50 to 275 deg F.
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
5. Length: As required by application to cover entire cross section of air tunnel.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch trade size.

I. Thermistor Outdoor Air Temperature Sensors:
1. Temperature Range: Minus 50 to 275 deg F.
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Solar Shield: Stainless steel.
4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
5. Conduit Connection: 1/2-inch trade size.

J. Thermistor Space Air Temperature Sensors:
1. Temperature Range: Minus 50 to 212 deg F.
2. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.

K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:
1. 100- or 1000-ohm platinum RTD or thermistor.
2. Thermistor:
a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
b. Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.
3. Temperature Transmitter Requirements:
a. Mating transmitter required with each 100-ohm RTD.
b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.
4. Provide digital display of sensed temperature.
5. Provide sensor with local control.
a. Local override to turn HVAC on.
b. Local adjustment of temperature set point.
c. Both features shall be capable of manual override through control system operator.

2.3 COMBINATION AIR TEMPERATURE SENSOR AND SWITCH

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. HONEYWELL.
2. JOHNSON CONTROLS.
3. SIEMENS.

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. Combination temperature sensor and switch in same instrument.

D. Air Temperature Switch:

1. Factory preset set point of 38 deg F. Field-adjustable set point from 30 to 44 deg F.
2. Responsive to coldest 12-inch section of sensor length.
3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual rest at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.

E. Air Temperature Sensor:

1. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
2. Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Accuracy: Within 0.9 deg F.
4. Output Signal: 4 to 20 mA for connection to remote monitoring.
5. Encase RTDs in a flexible nominal 0.375-inch- diameter sheath constructed of brass.
6. Lead wires shall be 18-gage AWG copper.
7. Enclosure: NEMA 250, Type 4.

2.4 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. HONEYWELL.
   b. JOHNSON CONTROLS.
   c. SIEMENS.
2. Description:
   a. Two-position control.
   b. Field-adjustable set point.
   c. Manual reset.
   d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Performance:
   a. Operating Temperature Range: 15 to 55 deg F.

b. Temperature Differential: 5 deg F, non-adjustable and additive.
c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
d. Sensing Element Maximum Temperature: 250 deg F.
e. Voltage: 120-V ac.
f. Current: 16 FLA.
g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.

4. Construction:
a. Vapor-Filled Sensing Element: Nominal 20 feet long.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch trade size.

2.5 AIR TEMPERATURE RTD TRANSMITTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. HONEYWELL.
2. JOHNSON CONTROLS.
3. SIEMENS.

B. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

C. House electronics in NEMA 250 enclosure.
1. Duct: Type 1.
2. Outdoor: Type 4X.
3. Space: Type 1.

D. Conduit Connection: 1/2-inch trade size.

E. Functional Characteristics:
1. Input:
a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
2. Span (Adjustable):
a. Space: 40 to 90 deg F.

b. Supply Air Cooling and Heating: 40 to 120 deg F.
c. Supply Air Cooling Only: 40 to 90 deg F.
d. Supply Air Heating Only: 40 to 120 deg F.
e. Exhaust Air: 50 to 100 deg F.
f. Return Air: 50 to 100 deg F.
g. Mixed Air: Minus 40 to 140 deg F.
h. Outdoor: Minus 40 to 140 deg F.

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together.

F. Performance Characteristics:
1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:
1. Duct Insert: Thermistor.
2. Outdoor: Thermistor.
3. Space: Thermistor.

3.3 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.
B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement.

C. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.4 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.5 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:
1. Roughing In:
a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.

2) Do not begin installation without submittal approval of mounting location.

c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.

3. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

4. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.

2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches.

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.

2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:
1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:
1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:
1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.7 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.8 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.9 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.

5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:
1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:
1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:
1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections:
1. Perform according to manufacturer's written instruction.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.11 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.12 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.13 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

B. Provide a complete set of instructional videos covering each product specified and installed and showing the following:

1. Software programming.
2. Calibration and test procedures.
3. Operation and maintenance requirements and procedures.
4. Troubleshooting procedures.

C. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

D. Record videos on DVD disks.

E. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.27

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SECTION 232300

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Copper tube and fittings.
   2. Valves and specialties.
   3. Refrigerants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Submit data for each type of refrigerant piping, fitting, valve, piping specialty, and refrigerant.

B. Shop Drawings:
   1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, at a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
   2. Show interface and spatial relationships between piping and equipment.

C. Delegated Design Submittal: For refrigerant piping design, including sizing and layout, oil traps, double risers, specialties, and pipe and tube sizes to accommodate, at a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Provide plans, piping schematics, and details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Welding Certificates: For each welder performing shop or field welding on Project.

C. Field Quality-Control Reports: For each field quality-control test and inspection.

D. Qualification Statements: For refrigerant piping design.
   1. Delegated design engineer qualifications.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with ASME Boiler and Pressure Vessel Code: Section IX, "Welding, Brazing, and Fusing Qualifications."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

B. Prepare valves and specialties for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads and other end connections.

C. Use the following precautions during storage:

1. Maintain valve and specialty end protection.
2. Store valves and specialties indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASHRAE 15 and ASHRAE 34.

B. Comply with ASME B31.5.

C. Test Pressure for Refrigerant R-410A:

1. Suction Tubing for Refrigeration and Air-Conditioning Applications Other than Heat Pumps: **300 psig (2068 kPa)**.
2. Hot-Gas and Tubing Lines: **535 psig (3689 kPa)**.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: **ASTM B88, Type K or L (ASTM B88M, Type A or B)**.

B. Wrought-Copper Fittings, Solder Joint: ASME B16.22.

C. Wrought-Copper Fittings, Brazed Joint: ASME B16.50.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

F. Brazing Filler Metals: AWS A5.8M/A5.8.

2.3 STEEL PIPE AND FITTINGS - NOT USED

2.4 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.

5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: **500 psig (3450 kPa)**.
7. Maximum Operating Temperature: **240 deg F (116 deg C)**.

B. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: **500 psig (3450 kPa)**.
8. Maximum Operating Temperature: **275 deg F (135 deg C)**.

C. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
8. Working Pressure Rating: **500 psig (3450 kPa)**.
9. Maximum Operating Temperature: **275 deg F (135 deg C)**.

D. Service Valves:
1. Body: Forged brass with brass cap, including key end to remove core.
2. Core: Removable ball-type check valve with stainless steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: **500 psig (3450 kPa)**.
6. Maximum Operating Temperature: **275 deg F (135 deg C)**.

E. Refrigerant Locking Caps:
1. Description: Locking-type, tamper-resistant, threaded caps to protect refrigerant-charging ports from unauthorized refrigerant access and leakage.
2. Material: Brass, with protective shroud or sleeve.
3. Refrigerant Identification: **Universal** design.
4. Special Tool: For installing and unlocking.

F. Solenoid Valves: Comply with AHRI 760 I-P (AHRI 761 SI) and UL 429; listed and labeled by an NRTL.
   1. Body and Bonnet: Plated steel.
   2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-mm) conduit adapter, and **115**V ac coil.
   6. Working Pressure Rating: **400 psig (2760 kPa)**.
   7. Maximum Operating Temperature: **240 deg F (116 deg C)**.

G. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
   2. Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Seat: Polytetrafluoroethylene.
   4. End Connections: Threaded.
   5. Working Pressure Rating: **400 psig (2760 kPa)**.
   6. Maximum Operating Temperature: **240 deg F (116 deg C)**.

H. Thermostatic Expansion Valves: Comply with AHRI 750 I-P (AHRI 751 SI).
   1. Body, Bonnet, and Seal Cap: Forged brass or steel.
   2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
   3. Packing and Gaskets: Non-asbestos.
   4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
   5. Suction Temperature: **40 deg F (4.4 deg C)**.
   6. Superheat: **Adjustable**.
   7. Reverse-flow option (for heat-pump applications).
   8. End Connections: Socket, flare, or threaded union.
   9. Working Pressure Rating: **700 psig (4820 kPa)**.

I. Straight-Type Strainers:
   1. Body: Welded steel with corrosion-resistant coating.
   2. Screen: 100-mesh stainless steel.
   3. End Connections: Socket or flare.
   4. Working Pressure Rating: **500 psig (3450 kPa)**.
   5. Maximum Operating Temperature: **275 deg F (135 deg C)**.

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: **500 psig (3450 kPa)**.
6. Maximum Operating Temperature: **275 deg F (135 deg C)**.

K. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color-coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: **500 psig (3450 kPa)**.
7. Maximum Operating Temperature: **240 deg F (116 deg C)**.

L. Permanent Filter Dryers: Comply with AHRI 730 I-P (AHRI 731 SI).

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless steel support.
3. Desiccant Media: Activated **alumina**.
4. Design: Reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: **2 psig (14 kPa)**.
8. Rated Flow: Size for unit.
9. Working Pressure Rating: **500 psig (3450 kPa)**.
10. Maximum Operating Temperature: **240 deg F (116 deg C)**.

M. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: **500 psig (3450 kPa)**.
4. Maximum Operating Temperature: **275 deg F (135 deg C)**.

N. Receivers: Comply with AHRI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.

3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid-level indicator, and safety-relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: **450 psig (3100 kPa)**.
7. Maximum Operating Temperature: **250 deg F (121 deg C)**.

O. Liquid Accumulators: Comply with AHRI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: **500 psig (3450 kPa)**.
4. Maximum Operating Temperature: **275 deg F (135 deg C)**.

2.5 REFRIGERANTS

A. R-410A, ASHRAE 34: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATION SCHEDULES

A. Refrigerant: **R-410A**.

B. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with **brazed** joints.

C. Safety-Relief-Valve Discharge Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, Copper: **Type K (A) or Type L (B)**, **drawn-temper or annealed-temper** tubing and wrought-copper fittings with **brazed** joints.

D. Safety-Relief-Valve Discharge Piping for Conventional Air-Conditioning (Cooling-Only) Applications, Steel: Schedule 40, black steel and wrought-steel fittings with welded joints.

E. Suction, Hot-Gas, and Liquid Tubing for Heat-Pump Applications, NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with **brazed** joints.

F. Safety-Relief-Valve Discharge Tubing for Heat-Pump Applications, Copper: **Type K (A) or Type L (B)**, **drawn-temper or annealed-temper** tubing and wrought-copper fittings with **brazed** joints

G. Safety-Relief-Valve Discharge Piping for Heat-Pump Applications, Steel: Schedule 40, black steel and wrought-steel fittings with welded joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install **diaphragm packless** or **packed-angle** valves in suction and discharge lines of compressor.

B. Install service valves for gauge taps at inlet and outlet of strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install **diaphragm packless** or **packed-angle** valves on inlet and outlet side of filter dryers.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   1. Install valve so diaphragm case is warmer than bulb.
   2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety-relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside in accordance with ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve**, and in the suction line at the compressor**.

L. Install receivers sized to accommodate pump-down charge.

M. Provide refrigerant locking caps on refrigerant charging ports that are located outdoors unless otherwise protected from unauthorized access by a means acceptable to authority having jurisdiction.

3.3 INSTALLATION OF PIPING, GENERAL

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping in accordance with ASHRAE 15.
C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
E. Install piping adjacent to machines to allow service and maintenance.
F. Install piping free of sags and bends.
G. Install fittings for changes in direction.
H. Select system components with pressure rating equal to or greater than system operating pressure.
I. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
J. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.
K. Install refrigerant piping in protective conduit where installed below ground.
L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
M. Slope refrigerant piping as follows:
    1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    2. Install horizontal suction lines with a uniform slope downward to compressor.
    3. Install traps and double risers to entrain oil in vertical runs.
    4. Liquid lines may be installed level.
N. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
P. Identify refrigerant piping and valves in accordance with Section 230553 "Identification for HVAC Piping and Equipment."
Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
D. Brazed Joints: Construct joints in accordance with AWS BRH, "Brazing Handbook," Ch. 35, "Pipe and Tubing."
    1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
    2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.
E. Threaded Joints: Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:
    1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
    2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
F. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic restraints in Section 230548 "Vibration and Seismic Controls for HVAC."
B. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
C. Install the following pipe attachments:
    1. Adjustable steel clevis hangers for individual horizontal runs less than 20 ft. (6 m) long.
    2. Roller hangers and spring hangers for individual horizontal runs 20 ft. (6 m) or longer.
    3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 ft. (6 m) or longer, supported on a trapeze.
    4. Spring hangers to support vertical runs.
    5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
D. Install hangers for **copper tubing** with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
E. Support horizontal piping within **12 inches (300 mm)** of each fitting.

F. Support vertical runs of **copper tubing** to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: **Engage** a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
    a. Fill system with nitrogen to the required test pressure.
    b. System must maintain test pressure at the manifold gauge throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

C. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, in accordance with manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.

4. Open refrigerant valves but not bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

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SECTION 233113

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Sealants and gaskets.
5. Hangers and supports.
6. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

A. OSHPD: Office of Statewide Health Planning and Development (State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Sealants and gaskets.
2. Seismic-restraint devices.

B. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.

9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:
1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing

requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

D. Tie Rods: Galvanized steel, 1/4-inch- minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 3 inches.
   3. Sealant: Modified styrene acrylic.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   3. Shore A Hardness: Minimum 20.
   4. Water resistant.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Base: Synthetic rubber resin.
   3. Solvent: Toluene and heptane.
   4. Solids Content: Minimum 60 percent.
   5. Shore A Hardness: Minimum 60.
   6. Water resistant.
   7. Mold and mildew resistant.

8. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.6 SEISMIC-RESTRAINT DEVICES

A. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to

braced component at one end and to building structure at the other end. Include matching components and corrosio

B. n-resistant coating.

C. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of galvanized-steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested in accordance with ASTM E 488/E 488M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwis

C. e indicated.

D. Install ducts in maximum practical lengths with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

L. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.

N. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.

O. Branch Connections: Use lateral or conical branch connections.

3.2 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.4 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

F. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify

Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.
B. Leakage Tests:
1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, totaling no less than 25 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give 14 days' advance notice for testing.
C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.

2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use duct cleaning methodology as indicated in NADCA ACR.

C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

D. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

E. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.

7. Dedicated exhaust and ventilation components and makeup air systems.

F. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.8 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.

B. Supply Ducts:

1. Ducts Connected to Terminal Units:
   a. Pressure Class: Positive 1- inch wg.
   b. Minimum SMACNA Seal Class: B.
   c. SMACNA Leakage Class for Rectangular: 24.
   d. SMACNA Leakage Class for Round: 12.
2. Ducts Connected to Variable-Air-Volume Air-Handling Units:
   a. Pressure Class: Positive 3- inch wg.
   b. Minimum SMACNA Seal Class: B.

c. SMACNA Leakage Class for Rectangular: 3.

d. SMACNA Leakage Class for Round: 3.

C. Return Ducts:

1. Ducts Connected to Air-Handling Units:

a. Pressure Class: Negative 2- inch wg.

b. Minimum SMACNA Seal Class: B.

c. SMACNA Leakage Class for Rectangular: 24

d. SMACNA Leakage Class for Round: 12

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative 1- inch wg.

b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.

c. SMACNA Leakage Class for Rectangular: 24

d. SMACNA Leakage Class for Round and Flat Oval: 12.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm:

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.
   b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
   c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.

G. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Conical spin in.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

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SECTION 233300

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Flange connectors.
3. Turning vanes.
4. Flexible connectors.
5. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
   a. Special fittings.
   b. Manual volume damper installations.
   c. Coordinate ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
   d. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access door

B. s required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

C. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: G60.
2. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Standard leakage rating.
2. Suitable for horizontal or vertical applications.
3. Frames:
    a. Frame: Hat-shaped, 0.094-inch thick, galvanized sheet steel.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.

c. Stiffen damper blades for stability.

d. Galvanized-steel, 0.064 inch thick.

5. Blade Axles: Stainless steel.

6. Bearings:

a. Molded synthetic or stainless-steel sleeve.

b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

1. Standard leakage rating.

2. Suitable for horizontal or vertical applications.

3. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.

4. Blades:

a. Multiple or single blade.

b. Parallel- or opposed-blade design.

c. Stiffen damper blades for stability.

d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.

e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.

5. Blade Axles: Stainless steel or Nonferrous metal.

6. Bearings:

a. Molded synthetic or stainless-steel sleeve.

b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Aluminum.

C. Accessories:

1. Auxiliary switches for signaling or position indication.

2. Test and reset switches, damper mounted.

2.4 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.5 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

C. Vane Construction: Single wall.

2.6 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
   c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
   d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.

2.7 DUCT ACCESS PANEL ASSEMBLIES

A. Labeled according to UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

C. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

E. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.8 FLEXIBLE CONNECTORS

A. As manufactured by Thermaflex, Hart and Cooley or Approved Equal.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.9 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

H. Install access doors with swing against duct static pressure.

I. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.

3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

J. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

K. Install flexible connectors to connect ducts to equipment.

L. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

M. Connect flexible ducts to metal ducts with draw bands.

N. Install duct test holes where required for testing and balancing purposes.

O. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

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SECTION 233346

FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For flexible ducts.

1. Include plans showing locations and mounting and attachment details.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling pl

B. ans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 INSULATED FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.

1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4000 fpm.
3. Temperature Range: Minus 20 to plus 175 deg F.
4. Insulation R-Value: Comply with ASHRAE/IES 90.1.

2.3 FLEXIBLE DUCT CONNECTORS

A. Clamps: Nylon strap in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect diffusers to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.

D. Connect flexible ducts to metal ducts with draw bands.

E. Install duct test holes where required for testing and balancing purposes.

F. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

G. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 233346

SECTION 233416

CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Forward-curved centrifugal fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fan room layout and

B. relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.

C. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolators and supports.

B. Seismic Performance: Centrifugal fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2. Component Importance Factor: 1.0.

2.2 FORWARD-CURVED CENTRIFUGAL FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, direct-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.

3. Factory-installed and -wired disconnect switch.

B. Housings:

1. Housing Material: Reinforced steel.

2. Housing Coating: Hot-dip galvanized

C. Wheels:

1. Wheel Configuration: SWSI construction with a curved inlet flange, and a backplate fastened to shaft with setscrews.
2. Wheel and Blade Material: Steel.
3. Wheel and Blade Coating: Powder-baked enamel.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with setscrews.
5. Forward-Curved Wheels:
   a. Black-enameled or galvanized-steel construction with inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow.
   b. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with setscrews.

D. Shafts:
1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Bearings:
1. Prelubricated and Sealed Shaft Bearings:
   a. Self-aligning, pillow-block-type ball bearings.
   b. Ball-Bearing Rating Life: ABMA 9, L (50) at 200,000 hours.

F. Motor Enclosure: Totally enclosed, fan cooled.

G. Accessories:
1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.4 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Compliance: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify fans according to AMCA 99.

PART 3 - EXECUTION

3.1 INSTALLATION OF CENTRIFUGAL HVAC FANS

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Install floor- or roof-mounted centrifugal fans on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK AND PIPING CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.

9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
11. Remove and replace malfunctioning units and retest as specified above.

E. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

SECTION 233600

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Modulating, single-duct air terminal units.
2. Casing liner.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment**, seismic restraints,** and vibration isolation.

C. Delegated Design Submittal: For vibration isolation **and supports, and seismic restraints** indicated to comply with performance requirements and design criteria, including analysis data **signed and sealed by the qualified professional engineer responsible for their preparation**.

1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculate requirements for selecting vibration isolators**, supports, and seismic restraints**.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.

B. Seismic Qualification Data: For air terminal units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
a. Instructions for resetting minimum and maximum air volumes.
b. Instructions for adjusting software set points.

1.5 MAINTENANCE MATERIAL SUBMITTALS - NOT USED

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.

B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

D. Delegated Design: **Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to** design vibration isolation**, supports, and seismic restraints**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

E. Seismic Performance: Air terminal units shall withstand the effects of earthquake motions determined in accordance with **ASCE/SEI 7**. See Section 230548 "Vibration and Seismic Controls for HVAC."
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Component Importance Factor: **1.0**.

2.2 BYPASS, SINGLE-DUCT AIR TERMINAL UNITS - NOT USED

2.3 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

A. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: Minimum **22-gauge** thick galvanized steel.
   1. Casing Liner: Comply with requirements in "Casing Liner" Article below for **with "Foil-Faced Liner" Subparagraph**.
   2. Air Inlet: Round stub connection or slip and drive connections for duct attachment.
   3. Air Outlet: Slip and drive connections.
   4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

C. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   1. Maximum Damper Leakage: AHRI 880 rated, **2** percent or less of nominal airflow at **3-inch wg (750-Pa)** inlet static pressure.

D. Velocity Sensors: Multipoint array with velocity inlet sensors.

E. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless steel, machine-staked terminals secured with stainless steel hardware. Provide electric-resistance heating coils for air terminal units scheduled on Drawings.
   1. SCR controlled.
   2. Access door interlocked disconnect switch.
   3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
   4. Nickel chrome 80/20 heating elements.
   5. Airflow switch for proof of airflow.
   6. Fan interlock contacts.
   7. Fuses in terminal box for overcurrent protection (for coils of more than 48 A).

F. Direct Digital Controls:
   1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
      a. Occupied and unoccupied operating mode.
      b. Remote reset of airflow or temperature set points.
      c. Adjusting and monitoring with portable terminal.
      d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
   2. Room Sensor: Wall mounted with [**temperature set-point adjustment and**] access for connection of portable operator terminal.

3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, integrated actuators, and room sensors to be furnished under Section 230923 "Direct Digital Controls (DDC) for HVAC."

G. Control Sequence: See **Drawings** for control sequences.

2.4 PARALLEL FAN-POWERED AIR TERMINAL UNITS - NOT USED

2.5 SERIES FAN-POWERED AIR TERMINAL UNITS - NOT USED

2.6 DUAL-DUCT AIR TERMINAL UNITS - NOT USED

2.7 INDUCTION AIR TERMINAL UNITS - NOT USED

2.8 DIFFUSER-TYPE AIR TERMINAL UNITS - NOT USED

2.9 BALANCING TERMINAL UNITS - NOT USED

2.10 PRESSURE-CONTROL TERMINAL UNITS - NOT USED

2.11 CRITICAL ENVIRONMENT CONTROL VALVE - NOT USED

2.12 UNDERFLOOR AIR DISTRIBUTION TERMINAL UNITS - NOT USED

2.13 EXHAUST SINGLE-DUCT TERMINAL UNITS - NOT USED

2.14 DOAS, SERIES, FAN-POWERED AIR TERMINAL UNITS - NOT USED

2.15 CASING LINER

A. Casing Liner, Fibrous Glass: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A or NFPA 90B, and with NAIMA AH124.

1. Minimum Thickness: **1 inch (25 mm)**.

a. Maximum Thermal Conductivity:

1) Type II, Rigid: **0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K)** at 75 deg F (24 deg C) mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to surface of liner that will form interior surface of duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

3. Foil-Faced Liner: Minimum 0.001-inch (0.03-mm) reinforced, nonporous aluminum foil applied to matted insulation airstream face.

2.16 SOURCE QUALITY CONTROL

A. **AHRI 880 Certification: Test, rate, and label assembled air terminal units in accordance with AHRI 880.**

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "Metal Ducts" for hangers and supports.

B. Install air terminal units according to NFPA 90A.

C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

D. Install wall-mounted thermostats.

3.2 PIPING CONNECTIONS - NOT USED

3.3 DUCTWORK CONNECTIONS

A. Comply with requirements in **Section 233113 "Metal Ducts"** for connecting ducts to air terminal units.

B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows**, and coil type**. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.7 STARTUP SERVICE

A. **Perform** startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.9 FIELD QUALITY CONTROL

A. Testing Agency: **Contractor** will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air terminal unit will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. **Train** Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713.13

AIR DIFFUSERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Rectangular and square ceiling diffusers.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
2. Section 233713.23 "Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.

C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.

D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected c3eiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

A. Titus, Price, Nailor

B. Devices shall be specifically designed for constant air volume flows.

C. Material: Steel.

D. Finish: Baked enamel, white.

E. Face Size: 24 by 24 inches.

F. Face Style: Four cone.

G. Mounting: Surface or T-bar.

H. Pattern: Adjustable.

I. Accessories:

1. Equalizing grid.
2. Plaster ring.

2.2 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

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SECTION 233713.23

REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Adjustable blade face registers.
2. Fixed face grilles.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Register and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples: For each exposed product and for each color and texture specified. Smallest size register and grille indicated.

C. Samples for Initial Selection: For registers and grilles with factory-applied color finishes. Smallest size register and grille indicated.

D. Samples for Verification: For registers and grilles, in manufacturer's standard sizes to verify color selected. Smallest size register and grille indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling pl

B. ans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

5. Duct access panels.

C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 REGISTERS

A. Adjustable Blade Face Register:

1. Titus, Price, Nailor
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Horizontal spaced 3/4 inch apart.
5. Core Construction: Integral.
6. Rear-Blade Arrangement: Horizontal spaced 3/4 inch apart.
7. Frame: 1 inch wide.
8. Mounting: Concealed.
9. Damper Type: Adjustable opposed blade
10. Accessories:
    a. Front-blade gang operator.

2.2 GRILLES

A. Fixed Face Grille:

1. Titus, Price, Nailor
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Face Blade Arrangement: Horizontal; spaced 3/4 inch apart.
5. Face Arrangement: Perforated core.
6. Core Construction: Integral.
7. Frame: 1 inch wide.
8. Mounting: Lay in.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where registers and grilles are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install registers and grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with in

C. stallation, notify Architect for a determinatio

D. n of final location.

E. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

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SECTION 233713.43

SECURITY REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Security diffusers.
   2. Security grilles.

B. Related Requirements:
   1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
   2. Section 233713.13 "Air Diffusers" for various types of air diffusers.
   3. Section 233713.23 "Registers and Grilles" for registers and grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Data Sheet: Indicate materials of construction, finish, mounting details, and performance data including throw and drop, static-pressure drop, and noise ratings.
   2. Diffuser and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Source quality control reports.

PART 2 - PRODUCTS

2.1 SECURITY REGISTERS - NOT USED

2.2 SECURITY DIFFUSERS AND GRILLES

A. Security Diffusers:
   1. Security Level: Minimum.
   2. Application: **Ducted supply**.
   3. Material: **Steel**.
   4. Material Thickness: 12 gauge (0.1 inch).
   5. Finish: Prime coat for field finish.
   6. Face Arrangement:
      a. Shape: **Square**.
      b. Design: **Lattice**.

c. Frame: **Yes**.
d. Deflection: **Zero**.
e. Core: **Louvered**.
f. 3/16 inch (5 mm) thick, front lattice plate with 13/16 inch (20.6 mm) square holes on 1 inch centers.

7. Mounting: **1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame and tamperproof machine screws**.

B. Security Grilles:

1. Security Level: Minimum.
2. Application: **Ducted return**.
3. Material: **Steel**.
4. Material Thickness: 12 gauge (0.1 inch).
5. Finish: Prime coat for field finish.
6. Face Arrangement:
   a. Shape: **Square**.
   b. Design: **Lattice**.
   c. Frame: **Yes**.
   d. Deflection: **Zero**.
   e. Core: **None.**
   f. 3/16 inch (5 mm) thick, front lattice plate with 13/16 inch (20.6 mm) square holes on 1 inch centers.
7. Mounting: **1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame and tamperproof machine screws**.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers and grilles in accordance with ASHRAE 70.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where security diffusers and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SECURITY REGISTERS AND GRILLES

A. Install security diffusers and grilles level and plumb.
B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where

indicated, as much as practical. Where architectural features, lighting fixtures, sprinklers, or other items conflict with installation, coordinate with other trades and notify Architect for a determination of final location.

C. Install security diffusers and grilles with airtight connections to ducts.

D. Provide access to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust security diffusers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.43

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SECTION 237416.13

PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Requirements:

1. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components.

1.2 DEFINITIONS

A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.3 ACTION SUBMITTALS

A. Product Data: For each RTU.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. Fans:
    a. Include certified fan-performance curves with system operating conditions indicated.
    b. Include certified fan-sound power ratings.
    c. Include fan construction and accessories.
    d. Include motor ratings, electrical characteristics, and motor accessories.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include dampers, including housings, linkages, and operators.

B. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning unit.

1. Include plans, elevations, sections, and [**mounting**] [**attachment**] details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   1. Include design calculations for selecting vibration isolators [**and seismic restraints**] and for designing vibration isolation bases.
   2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   3. Restraint Details: **Wind and seismic** detail fabrication and attachment of **wind and** seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
B. Sample Warranty: For manufacturer's warranty.
C. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
   4. Restraint of internal components.
D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
E. Source quality-control reports.
F. System startup reports.
G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Filters: **One** set of filters for each unit.
   2. Gaskets: **One** set for each access door.
   3. Fan Belts: **One** for each belt-driven fan.

1.7 WARRANTY

A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: 1 year from date of Substantial Completion.
   2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than **five** years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.

C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE 15 Compliance: For refrigeration system safety.

E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. UL Compliance: Comply with UL 1995.

G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.
   1. Design RTU supports to comply with **wind and seismic** performance requirements.

H. Wind-Restraint Performance:
   1. Basic Design Wind Speed: 150 mph.

2. Minimum **10 lb/sq. ft. (48.8 kg/sq. m)** multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

I. Seismic Performance: RTUs, accessories, and components to withstand the effects of earthquake motions. See Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" and Section 018123 "Facility Seismic and Wind Criteria" for building seismic performance criteria.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified **and the unit will be fully operational after the seismic event**."
2. Component Importance Factor: **1.5**.

2.2 CAPACITIES AND CHARACTERISTICS - NOT USED

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

C. Panels and Doors:

1. Panels:
   a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
   b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
   c. Gasket: Neoprene, applied around entire perimeters of panel frames.
   d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
2. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
3. Locations and Applications:

a. Fan Section: Doors and inspection and access panels.
b. Access Section: Doors.
c. Coil Section: Inspection and access panels.
d. Damper Section: Inspection and access panels.
e. Filter Section: **Doors** large enough to allow periodic removal and installation of filters.

D. Condensate Drain Pans:
1. Location: Each type of cooling coil.
2. Construction:
a. Single-wall, stainless steel sheet.
3. Drain Connection:
a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on **one end** of pan.
b. Minimum Connection Size: **NPS 1-1/4.**
4. Slope: Minimum **0.125-in./ft.** slope**, to comply with ASHRAE 62.1,** in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
5. Width: Entire width of water producing device.
6. Depth: A minimum of **2 inches** deep.
7. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
8. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.4 FANS, DRIVES, AND MOTORS

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.
1. Shafts: With field-adjustable alignment.
a. Turned, ground, and polished hot-rolled steel with keyway.
2. Shaft Bearings:
a. Heavy-duty, self-aligning, pillow-block type with an **L-50** rated life of minimum **100,000** hours according to ABMA 9.
3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
5. Mounting: For internal vibration isolation **and seismic control**. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of **1 inch.**
6. Shaft Lubrication Lines: Extended to a location outside the casing.
7. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch wide by 0.028-inch thick, galvanized-steel sheet.
   a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

C. Drives, Direct: Factory-mounted, direct drive.

D. Drives, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with **1.5** service factor based on fan motor.
   1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
   2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
   3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; **0.146-inch** thick, **3/4-inch** diamond-mesh wire screen, welded to steel angle frame; prime coated.

E. Condenser-Coil Fan: **Variable-speed** propeller, mounted on shaft of permanently lubricated motors.

F. Motors:
   1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
   2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   3. Enclosure Type: Totally enclosed, fan cooled.
   4. Motor Pulleys: Adjustable pitch for use with **5**-hp motors and smaller; fixed pitch for use with motors larger than **5**-hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
   5. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.5 COILS

A. General Requirements for Coils:
   1. Comply with AHRI 410.
   2. Fabricate coils section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
   3. Coils shall not act as structural component of unit.

B. Supply-Air Refrigerant Coil:
   1. Tubes: Copper.
   2. Fins:
      a. Material: Aluminum.
      b. Fin Spacing: Maximum **12** fins per inch.
   3. Fin and Tube Joints: Mechanical bond.
   4. Headers: Seamless-copper headers with brazed connections.
   5. Frames: Galvanized steel.
   6. Coatings: Corrosion-resistant coating.
   7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
      a. Working Pressure: Minimum 300 psig.

2.6 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, **variable speed** scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief**, and crankcase heater**.

B. Refrigeration Specialties:
   1. Refrigerant: R-410A.
   2. Expansion valve with replaceable thermostatic element.
   3. Refrigerant filter/dryer.
   4. Manual-reset high-pressure safety switch.
   5. Automatic-reset low-pressure safety switch.
   6. Minimum off-time relay.
   7. Automatic-reset compressor motor thermal overload.
   8. Brass service valves installed in compressor suction and liquid lines.
   9. Low-ambient kit high-pressure sensor.

2.7 AIR FILTRATION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. Panel Filters:
   1. Description: **Pleated** factory-fabricated, self-supported, disposable air filters with holding frames.

2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
4. Filter-Media Frame: **Beverage board** with perforated metal retainer, or metal grid, on outlet side.

2.8 GAS FURNACES - NOT USED

2.9 DAMPERS

A. Comply with requirements in Section 230923.12 "Control Dampers."
B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, **galvanized-steel** dampers with compressible jamb seals and extruded-vinyl blade edge seals in **opposed**-blade arrangement with steel operating rods rotating in **sintered bronze or nylon** bearings mounted in a single **galvanized-steel** frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg** rated in accordance with AMCA 500D.
C. Barometric relief dampers.
D. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
E. Electronic Damper Operators:
    1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
    2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
    3. Operator Motors:
        a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
        b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
        c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

2.10 ELECTRICAL POWER CONNECTIONS

A. RTU is to have a single connection of power to unit with [**unit-mounted disconnect switch accessible from outside unit and**] control-circuit transformer with built-in overcurrent protection.

2.11 CONTROLS

A. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:
    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Fan-speed switch.
    d. **Automatic** changeover.
    e. Adjustable deadband.
    f. **Concealed** set point.
    g. **Concealed** indication.
    h. **Degree F** indication.
    i. Unoccupied-period-override push button.
    j. Data entry and access port to input temperature **and humidity** set points, occupied and unoccupied periods, and output room temperature **and humidity**, supply-air temperature, operating mode, and status.

2.12 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
    1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
        a. Materials: ASTM C1071, Type I or II.
        b. Thickness: **2 inches.**
    2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
        a. Liner Adhesive: Comply with ASTM C916, Type I.
        b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
        c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    3. Curb Dimensions: Height of **14 inches.**

2.13 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. **Outlet shall be energized even if the unit main disconnect is open.**

B. Low-ambient kit using **variable-speed** condenser fans for operation down to **35 deg F.**

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure drop.

D. Remote potentiometer to adjust minimum economizer damper position.

E. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. High **and low** pressure control.

F. Outdoor air intake weather hood.

1. Service Lights and Switch: Factory installed in **each accessible section** with weatherproof cover. Factory wire lights to a single-point field connection.

2.14 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

B. Stainless Steel:

1. Manufacturer’s standard grade for casing.
2. Manufacturer’s standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Corrosion-Resistant Coating:

1. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
2. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a **3000-**hour salt-spray test according to ASTM B117.
   a. Standards:
      1) ASTM B117 for salt spray.
      2) ASTM D2794 for minimum impact resistance of 100 in-lb.
      3) ASTM B3359 for cross-hatch adhesion of 5B.
   b. Application: Immersion.
   c. Thickness: **1 mil.**
   d. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.15 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.

2. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs
3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA COMPLIANCE
1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested in accordance with AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.
B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.
C. Examine roofs for suitable conditions where RTUs will be installed.
D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DUCT CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.

3.3 ELECTRICAL CONNECTIONS

A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2 inch high.
3. Locate nameplate where easily visible.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.
B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
B. Perform tests and inspections.
C. Tests and Inspections:
   1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
D. RTU will be considered defective if it does not pass tests and inspections.
E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. **Engage a factory-authorized service representative to perform** startup service.
B. Complete installation and startup checks according to manufacturer's written instructions.
   1. Inspect for visible damage to unit casing.
   2. Inspect for visible damage to compressor, coils, and fans.
   3. Inspect internal insulation.
   4. Verify that labels are clearly visible.
   5. Verify that clearances have been provided for servicing.
   6. Verify that controls are connected and operable.
   7. Verify that filters are installed.
   8. Clean condenser coil and inspect for construction debris.
   9. Remove packing from vibration isolators.
   10. Inspect operation of barometric relief dampers.
   11. Verify lubrication on fan and motor bearings.
   12. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

13. Adjust fan belts to proper alignment and tension.
14. Start unit according to manufacturer's written instructions.
    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.
15. Inspect and record performance of interlocks and protective devices; verify sequences.
16. Operate unit for an initial period as recommended or required by manufacturer.
17. Calibrate thermostats.
18. Adjust and inspect high-temperature limits.
19. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
20. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
21. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
22. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
    a. Supply-air volume.
    b. Return-air volume.
    c. Outdoor-air intake volume.
23. Simulate maximum cooling demand and inspect the following:
    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
24. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
    a. Low-temperature safety operation.
    b. Filter high-pressure differential alarm.
    c. Economizer to minimum outdoor-air changeover.
    d. Smoke and firestat alarms.
25. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.7 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

C. Occupancy Adjustments: When requested within **12** months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **two** visits to Project during other-than-normal occupancy hours for this purpose.

3.8 CLEANING

A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems and after completing startup service, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.9 FIELD QUALITY CONTROL

A. Testing Agency:

1. Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections [**with the assistance of a factory-authorized service representative**]:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. RTU will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DEMONSTRATION

A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.13

SECTION 238216.14

ELECTRIC-RESISTANCE AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Electric-resistance air coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
   2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

A. Altitude above Mean Sea Level: 33 **feet (10 m)**.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Coil Assembly: Comply with UL 1995.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

E. Equally balance heater electrical load for each step across all electrical phases.

F. Part-Load Operation: Provide arrangement with operation staged for uninterrupted operation over the full range of airflow down to the minimum airflow indicated.

G. Capacities and Characteristics:
   1. Mounting: **Slip in**.
   2. Air Side:
      a. As noted in Drawings.
   3. Electrical Characteristics:
      a. As noted in Drawings.

2.2 ELECTRIC-RESISTANCE AIR COILS

A. Source Limitations: Obtain electric-resistance air coils from single source from single manufacturer.

B. Heating Elements:
   1. Open Elements:
      a. Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in a frame.
      b. Safety Screens: Install safety screens to protect operators from accidentally coming into direct connect with elements.
   2. Finned Tubular Elements:
      a. Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
      b. Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.
      c. Each element individually removable from terminal box.
      d. Use threaded stainless steel element terminals and hardware.

C. Frame: **Galvanized** steel; minimum **0.052 inch (1.3 mm)** thick for **slip-in** mounting. Include intermediate element support brackets equally spaced at a maximum of **36 inches (900 mm)** o.c. across electric-resistance air coil.

D. Control Panel: **Unit mounted**; with disconnection means and overcurrent protection.
   1. Enclosure: NEMA 250, **Type 1** enclosure complying with UL 50.
   2. Full-face-hinged door **with lock and key latching device(s)**.
   3. Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible be service personnel. Wiring diagram to match installation.

E. Controls:
   1. Safety Controls: Each heater is to be provided with the following factory-mounted safety controls:

a. Disk-type thermal cutout switch with automatic reset.
b. Primary linear thermal limit cutout switch with automatic reset.
c. Secondary linear thermal limit cutout switch with local manual reset.
d. Airflow Proving Switch: Pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.

2. Staging Control: Magnetic contactors for switching stages of heat.
3. SCR Control: Silicone-controlled rectifier (SCR) for 100 percent stepless capacity control.
4. Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals, including the following:
   a. Heater on/off control.
   b. Monitoring heater on/off status.
   c. High-temperature alarm.
   d. Low-airflow alarm.
   e. Heater capacity control.

F. Electrical:
1. Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.
2. Disconnecting Means: Provide each heater with a main electrical power connection, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched to the off position.
   a. **Non-fused disconnect switch** with lockable handle.
   b. Minimum Short-Circuit Current Rating: As required by electrical power distribution system.
3. Factory install and wire branch circuit fusing or circuit breakers in accordance with NFPA 70.
4. Pilot Lights: Include labeled pilot lights on face of control panel for the following:
   a. Power on.
   b. Low-airflow alarm.
   c. High-temperature alarm.
5. Terminations: Wire terminations and field interface terminations to labeled terminal strips.
6. Control Transformer: Size control circuit transformer for load.
7. Labeling: Label each electrical device with a laminated phenolic tag.
8. Use only NRTL-labeled electrical components.

G. Nameplate: Include the following data:
1. Manufacturer name, address, telephone number, and website address.

2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).

H. See Section 230923.27 "Temperature Instruments" for thermostat.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least **1/2 inch (13 mm)** high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: **Engage** a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Prepare test and inspection reports.

END OF SECTION 238216.14

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SECTION 260010

SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements generally applicable to all electrical Work on the Project, including but not limited to Work specified in Divisions 26, 27, and 28.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Terms and Units of Measure:

1. 8P8C: An 8-position 8-contact modular jack.
2. A: Ampere, unit of electrical current.
3. AC or ac: Alternating current.
4. AFCI: Arc-fault circuit interrupter.
5. AIC: Ampere interrupting capacity.
6. AL, Al, or ALUM: Aluminum.
7. ASD: Adjustable-speed drive.
8. ATS: Automatic transfer switch.
9. AWG: American wire gauge; see ASTM B258.
10. BAS: Building automation system.
11. BIL: Basic impulse insulation level.
12. BIM: Building information modeling.
13. BMS: Building management system.
14. CAD: Computer-aided design or drafting.
15. CATV: Community antenna television.
16. CB: Circuit breaker.
17. cd: Candela, the SI fundamental unit of luminous intensity.
18. CO/ALR: Copper-aluminum, revised.
19. COPS: Critical operations power system.
20. CU or Cu: Copper.

21. CU-AL or AL-CU: Copper-aluminum.
22. dB: Decibel, a unitless logarithmic ratio of two electrical, acoustical, or optical power values.
23. dB(A-weighted) or dB(A): Decibel acoustical sound pressure level with A-weighting applied in accordance with IEC 61672-1.
24. dB(adjusted) or dBa: Decibel weighted absolute noise power with respect to 3.16 pW (minus 85 dBm).
25. dBm: Decibel absolute power with respect to 1 mW.
26. DC or dc: Direct current.
27. DCOA: Designated critical operations area.
28. DDC: Direct digital control (HVAC).
29. EGC: Equipment grounding conductor.
30. ELV: Extra-low voltage.
31. EMF: Electromotive force.
32. EMI: Electromagnetic interference.
33. EMP: Electrical maintenance program (operation and maintenance); electromagnetic pulse (transient analysis).
34. EPS: Emergency power supply.
35. EPSS: Emergency power supply system.
36. ESS: Energy storage system.
37. EV: Electric vehicle.
38. EVPE: Electric vehicle power export equipment.
39. EVSE: Electric vehicle supply equipment.
40. FACU: Fire-alarm control unit.
41. fc: Footcandle, an internationally recognized unit of illuminance equal to one lumen per square foot or 10.76 lx. The simplified conversion 1 fc = 10 lx in the Specifications is common practice and considered adequate precision for building construction activities. When there are conflicts, lux is the primary unit; footcandle is specified for convenience.
42. FLC: Full-load current.
43. ft: Foot.
44. ft-cd: Foot-candle, the antiquated U.S. standard unit of illuminance, equal to one international candle measured at a distance of one foot, that was superseded in 1948 by the unit "footcandle" when the SI unit candela (cd) replaced the international candle; see "fc."
45. FTP: File transfer protocol.
46. GEC: Grounding electrode conductor.

47. GFCI: Ground-fault circuit interrupter.
48. GFPE: Ground-fault protection of equipment.
49. GND: Ground.
50. HACR: Heating, air conditioning, and refrigeration.
51. HDPE: High-density polyethylene.
52. HID: High-intensity discharge.
53. HP or hp: Horsepower.
54. HVAC: Heating, ventilating, and air conditioning.
55. Hz: Hertz.
56. IBT: Intersystem bonding termination.
57. ICT: Information and communications technology.
58. inch: Inch. To avoid confusion, the abbreviation "in." is not used.
59. I/O: Input/output.
60. IP: Ingress protection rating (enclosures); Internet protocol (communications).
61. IR: Infrared.
62. IS: Intrinsically safe.
63. IT&R: Inspecting, testing, and repair.
64. ITE: Information technology equipment.
65. kAIC: Kiloampere interrupting capacity.
66. kcmil or MCM: One thousand circular mils.
67. kV: Kilovolt.
68. kVA: Kilovolt-ampere.
69. kvar: Kilovolt-ampere reactive.
70. kW: Kilowatt.
71. kWh: Kilowatt-hour.
72. LAN: Local area network.
73. lb: Pound (weight).
74. lbf: Pound (force).
75. LCD: Liquid-crystal display.
76. LCDI: Leakage-current detector-interrupter.
77. LED: Light-emitting diode.
78. Li-ion: Lithium-ion.
79. lm: Lumen, the SI-derived unit of luminous flux.
80. LNG: Liquefied natural gas.
81. LP-Gas: Liquefied petroleum gas.

82. LRC: Locked-rotor current.
83. LV: Low voltage.
84. lx: Lux, the SI-derived unit of illuminance equal to one lumen per square meter.
85. m: Meter.
86. MCC: Motor-control center.
87. MDC: Modular data center.
88. MG set: Motor-generator set.
89. MIDI: Musical instrument digital interface.
90. MLO: Main lugs only.
91. MPEG-2: Abbreviation for the ISO/IEC Moving Picture Experts Group's standard for generic coding of moving pictures and associated audio information (ISO/IEC 13818) released in 1995 and used for most over-the-air and satellite broadcast digital television.
92. MPEG-4: Abbreviation for the ISO/IEC Moving Picture Experts Group's standard framework for coding of audio-visual objects (ISO/IEC 14496) released in 1999, with digital rights management and more advanced compression algorithms than MPEG-2.
93. MOV: Metal-oxide varistor.
94. MV: Medium voltage.
95. MVA: Megavolt-ampere.
96. mW: Milliwatt.
97. MW: Megawatt.
98. MWh: Megawatt-hour.
99. N.C.: Normally closed.
100. Ni-Cd: Nickel-cadmium.
101. Ni-MH: Nickel-metal hydride.
102. NIU: Network interface unit.
103. N.O.: Normally open.
104. NPT: National (American) standard pipe taper.
105. OCPD: Overcurrent protective device.
106. ONT: Optical network terminal.
107. PC: Personal computer.
108. PCS: Power conversion system.
109. PCU: Power-conditioning unit.
110. PF or pf: Power factor.
111. PHEV: Plug-in hybrid electric vehicle.
112. PLC: Programmable logic controller.

113. PLFA: Power-limited fire alarm.
114. PoE: Power over Ethernet.
115. POTS: Plain old telephone service. See "public switched telephone network" definition.
116. PSTN: Public switched telephone network.
117. PV: Photovoltaic.
118. PVC: Polyvinyl chloride.
119. pW: Picowatt.
120. RFI: (electrical) Radio-frequency interference; (contract) Request for interpretation.
121. RMS or rms: Root-mean-square.
122. RPM or rpm: Revolutions per minute.
123. SCADA: Supervisory control and data acquisition.
124. SCCR: Short-circuit current rating.
125. SCR: Silicon-controlled rectifier.
126. SPD: Surge protective device.
127. sq.: Square.
128. SWD: Switching duty.
129. TCP/IP: Transmission Control Protocol/Internet Protocol.
130. TEFC: Totally enclosed fan-cooled.
131. TR: Tamper resistant.
132. TVSS: Transient voltage surge suppressor.
133. UL: (standards) UL Standards & Engagement Inc.; (product categories) UL, LLC.
134. UL CCN: UL Category Control Number.
135. UPS: Uninterruptible power supply.
136. USB: Universal serial bus.
137. UV: Ultraviolet.
138. V: Volt, unit of electromotive force.
139. V(ac): Volt, alternating current.
140. V(dc): Volt, direct current.
141. VA: Volt-ampere, unit of complex electrical power.
142. VAR: Volt-ampere reactive, unit of reactive electrical power.
143. VFC: Variable-frequency controller.
144. VOM: Volt-ohm-multimeter.
145. VoIP: Voice over Internet Protocol.
146. VPN: Virtual private network.

147. VRLA: Valve regulated lead acid; also called "sealed lead acid (SLA)" or "valve regulated sealed lead acid."
148. W: Watt, unit of real electrical power.
149. WAN: Wide area network.
150. Wh: Watt-hour, unit of electrical energy usage.
151. WPT: Wireless power transfer.
152. WPTE: Wireless power transfer equipment.
153. WR: Weather resistant.

B. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-A: Aluminum electrical metallic tubing.
3. EMT-S: Steel electrical metallic tubing.
4. EMT-SS: Stainless steel electrical metallic tubing.
5. ENT: Electrical nonmetallic tubing.
6. EPEC: Electrical HDPE underground conduit (thin wall).
7. EPEC-A: Type A electrical HDPE underground conduit.
8. EPEC-B: Type B electrical HDPE underground conduit.
9. ERMC: Electrical rigid metal conduit.
10. ERMC-A: Aluminum electrical rigid metal conduit.
11. ERMC-S: Steel electrical rigid metal conduit.
12. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
13. ERMC-S-PVC: PVC-coated-steel electrical rigid metal conduit.
14. ERMC-SS: Stainless steel electrical rigid metal conduit.
15. FMC: Flexible metal conduit.
16. FMC-A: Aluminum flexible metal conduit.
17. FMC-S: Steel flexible metal conduit.
18. FMT: Steel flexible metallic tubing.
19. FNMC: Flexible nonmetallic conduit. See "LFNC."
20. HDPE: HDPE underground conduit (thick wall).
21. HDPE-40: Schedule 40 HDPE underground conduit.
22. HDPE-80: Schedule 80 HDPE underground conduit.
23. IMC: Steel electrical intermediate metal conduit.
24. LFMC: Liquidtight flexible metal conduit.
25. LFMC-A: Aluminum liquidtight flexible metal conduit.
26. LFMC-S: Steel liquidtight flexible metal conduit.

27. LFMC-SS: Stainless steel liquidtight flexible metal conduit.
28. LFNC: Liquidtight flexible nonmetallic conduit.
29. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
30. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
31. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
32. PVC: Rigid PVC conduit.
33. PVC-40: Schedule 40 rigid PVC conduit.
34. PVC-80: Schedule 80 rigid PVC Conduit.
35. PVC-A: Type A rigid PVC concrete-encased conduit.
36. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.
37. RGS: See ERMC-S-G.
38. RMC: See ERMC.
39. RTRC: Reinforced thermosetting resin conduit.
40. RTRC-AG: Low-halogen, aboveground reinforced thermosetting resin conduit.
41. RTRC-AG-HW: Heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
42. RTRC-AG-SW: Standard wall, low-halogen, aboveground reinforced thermosetting resin conduit.
43. RTRC-AG-XW: Extra heavy wall, low-halogen, aboveground reinforced thermosetting resin conduit.
44. RTRC-BG: Low-halogen, belowground reinforced thermosetting resin conduit.

C. Abbreviations and Acronyms for Electrical Single-Conductor and Multiple-Conductor Cable Types:

1. AC: Armored cable.
2. CATV: Coaxial general-purpose cable.
3. CATVP: Coaxial plenum cable.
4. CATVR: Coaxial riser cable.
5. CI: Circuit integrity cable.
6. CL2: Class 2 cable.
7. CL2P: Class 2 plenum cable.
8. CL2R: Class 2 riser cable.
9. CL2X: Class 2 cable, limited use.
10. CL3: Class 3 cable.
11. CL3P: Class 3 plenum cable.
12. CL3R: Class 3 riser cable.

13. CL3X: Class 3 cable, limited use.
14. CM: Communications general-purpose cable.
15. CMG: Communications general-purpose cable.
16. CMP: Communications plenum cable.
17. CMR: Communications riser cable.
18. CMUC: Under-carpet communications wire and cable.
19. CMX: Communications cable, limited use.
20. DG: Distributed generation cable.
21. FC: Flat cable.
22. FCC: Flat conductor cable.
23. FPL: Power-limited fire-alarm cable.
24. FPLP: Power-limited fire-alarm plenum cable.
25. FPLR: Power-limited fire-alarm riser cable.
26. IGS: Integrated gas spacer cable.
27. ITC: Instrumentation tray cable.
28. ITC-ER: Instrumentation tray cable, exposed run.
29. MC: Metal-clad cable.
30. MC-HL: Metal-clad cable, hazardous location.
31. MI: Mineral-insulated, metal-sheathed cable.
32. MTW: (machine tool wiring) Moisture-, heat-, and oil-resistant thermoplastic cable.
33. MV: Medium-voltage cable.
34. NM: Nonmetallic sheathed cable.
35. NMC: Nonmetallic sheathed cable with corrosion-resistant nonmetallic jacket.
36. NMS: Nonmetallic sheathed cable with signaling, data, and communications conductors, plus power or control conductors.
37. NPLF: Non-power-limited fire-alarm circuit cable.
38. NPLFP: Non-power-limited fire-alarm circuit cable for environmental air spaces.
39. NPLFR: Non-power-limited fire-alarm circuit riser cable.
40. NUCC: Nonmetallic underground HDPE conduit with conductors.
41. OFC: Conductive optical fiber general-purpose cable.
42. OFCG: Conductive optical fiber general-purpose cable.
43. OFCP: Conductive optical fiber plenum cable.
44. OFCR: Conductive optical fiber riser cable.
45. OFN: Nonconductive optical fiber general-purpose cable.
46. OFNG: Nonconductive optical fiber general-purpose cable.

47. OFNP: Nonconductive optical fiber plenum cable.
48. OFNR: Nonconductive optical fiber riser cable.
49. P: Marine shipboard cable.
50. PLTC: Power-limited tray cable.
51. PLTC-ER: Power-limited tray cable, exposed run.
52. PV: Photovoltaic cable.
53. RHH: (high heat) Thermoset rubber, heat-resistant cable.
54. RHW: Thermoset rubber, moisture-resistant cable.
55. SA: Silicone rubber cable.
56. SE: Service-entrance cable.
57. SER: Service-entrance cable, round.
58. SEU: Service-entrance cable, flat.
59. SIS: Thermoset cable for switchboard and switchgear wiring.
60. TBS: Thermoplastic cable with outer braid.
61. TC: Tray cable.
62. TC-ER: Tray cable, exposed run.
63. TC-ER-HL: Tray cable, exposed run, hazardous location.
64. THW: Thermoplastic, heat- and moisture-resistant cable.
65. THHN: Thermoplastic, heat-resistant cable with nylon jacket outer sheath.
66. THHW: Thermoplastic, heat- and moisture-resistant cable.
67. THWN: Thermoplastic, moisture- and heat-resistant cable with nylon jacket outer sheath.
68. TW: Thermoplastic, moisture-resistant cable.
69. UF: Underground feeder and branch-circuit cable.
70. USE: Underground service-entrance cable.
71. XHH: Cross-linked polyethylene, heat-resistant cable.
72. XHHW: Cross-linked polyethylene, heat- and moisture-resistant cable.

D. Abbreviations and Acronyms for Electrical Flexible Cord Types:
1. SEO: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.
2. SEOW: 600 V extra-hard-usage, hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
3. SEOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp locations.

4. SEOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer covering for damp or wet locations.
5. SJEO: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
6. SJEOW: 300 V hard-usage, junior hard-service cord with thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
7. SJEOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp locations.
8. SJEOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic elastomer insulation and oil-resistant thermoplastic elastomer outer cover for damp or wet locations.
9. SJO: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp locations.
10. SJOW: 300 V hard-usage, junior hard-service cord with thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
11. SJOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp locations.
12. SJOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer cover for damp or wet locations.
13. SJTO: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
14. SJTOW: 300 V hard-usage, junior hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
15. SJTOO: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp locations.
16. SJTOOW: 300 V hard-usage, junior hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer cover for damp or wet locations.
17. SO: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp locations.
18. SOW: 600 V extra-hard-usage, hard-service cord with thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
19. SOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp locations.

20. SOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoset insulation and oil-resistant thermoset outer covering for damp or wet locations.
21. STO: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
22. STOW: 600 V extra-hard-usage, hard-service cord with thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.
23. STOO: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp locations.
24. STOOW: 600 V extra-hard-usage, hard-service cord with oil-resistant thermoplastic insulation and oil-resistant thermoplastic outer covering for damp or wet locations.

E. Definitions:

1. 8-Position 8-Contact (8P8C) Modular Jack: An unkeyed jack with up to eight contacts commonly used to terminate twisted pair and multiconductor Ethernet cable. Also called a "TIA-1096 miniature 8-position series jack" (8PSJ), or an "IEC 8877 8-pole jack."
    a. Be careful when suppliers use "RJ45" generically. Obsolete RJ45 jacks used for analog telephone cables have rejection keys. 8P8C jacks used for digital telephone cables and Ethernet cables do not have rejection keys.
2. Basic Impulse Insulation Level (BIL): Reference insulation level expressed in impulse crest voltage with a standard wave not longer than 1.5 times 50 microseconds and 1.5 times 40 microseconds.
3. Cable: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "cable" is (1) a conductor with insulation, or a stranded conductor with or without insulation (single-conductor cable); or (2) a combination of conductors insulated from one another (multiple-conductor cable).
4. Communications Jack: A fixed connecting device designed for insertion of a communications cable plug.
5. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.
6. Conductor: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "conductor" is (1) a wire or combination of wires not insulated from one another, suitable for carrying an electric current; (2) (National Electrical Safety Code) a material, usually in the form of wire, cable, or bar, suitable for carrying an electric current; or (3) (general) a substance or body that allows a current of electricity to pass continuously along it.
7. Conduit: A structure containing one or more duct raceways.

8. Designated Seismic System: An architectural, electrical, or mechanical system and its components for which the component importance factor is greater than 1.0 when determined in accordance with Section 018123 "Facility Seismic and Wind Criteria."
9. Direct Buried: Installed underground without encasement in concrete or other protective material.
10. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.
11. Duct Raceway: A single enclosed raceway for conductors or cable.
12. Electrical Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.
13. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:
    a. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
    b. Concrete Box: A box intended for use in poured concrete.
    c. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
    d. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
    e. Cover Plate: A cover designed for protecting wiring devices installed in flush-mounted device boxes while permitting their safe operation; also called a faceplate or wallplate.
    f. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
    g. Device Box: A box with provisions for mounting a wiring device directly to the box.
    h. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
    i. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
    j. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.

k. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.

l. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.

m. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.

n. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.

o. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.

p. Raised-Floor Box: A floor box intended for use in raised floors.

q. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.

r. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.

s. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.

t. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.

u. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

14. Emergency Systems: Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction that are designed to ensure continuity of lighting, electrical power, or both, to designated areas and equipment in the event of failure of the normal supply for safety to human life.

15. Essential Electrical Systems: (healthcare facilities) Those systems designed to ensure continuity of electrical power to designated areas and functions of a healthcare facility during disruption of normal power sources, and also to minimize disruption within the internal wiring system.

16. Fault Limited: Providing or being served by a source of electrical power that is limited to not more than 100 W when tested in accordance with UL 62368-1.
    a. The term "fault limited" is intended to encompass most Class 1, 2, and 3 power-limited sources complying with Article 725 of NFPA 70; Class ES1 and ES2 electrical energy sources that are Class PS1 electrical power sources (e.g., USB); and Class ES3 electrical energy sources that are Class PS1 and PS2 electrical power sources (e.g., PoE). See UL 62368-1 for discussion of classes of electrical energy sources and classes of electrical power sources.
17. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
18. Jacket: A continuous nonmetallic outer covering for conductors or cables.
19. Luminaire: A complete lighting unit consisting of a light source such as a lamp, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light.
20. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the Energy Independence and Security Act (EISA) of 2007.
21. Multi-Outlet Assembly: A type of surface, flush, or freestanding raceway designed to hold conductors, receptacles, and switches, assembled in the field or at the factory.
22. One-Line Diagram: A diagram that shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein. Also called "single-line diagram."
23. Plenum: A compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.
24. Protective Device: A device that senses when an abnormal current flow, abnormal voltage potential, or other abnormal electrical waveform exists and then disconnects the affected portion of the circuit from the system. Common protective devices include fuses, circuit breakers, relays, ground-fault circuit interrupters, and arc-fault circuit interrupters.
25. Public Switched Telephone Network (PSTN): Analog telephone technology that uses twisted pair cables from a telephone-provider central office for the transmission medium. "PSTN" refers to the telephone network; "POTS" refers to the individual subscriber line.
26. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.

27. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.
28. Sheath: A continuous metallic covering for conductors or cables.
29. UL Category Control Number (CCN): An alphabetic or alphanumeric code used to identify product categories covered by UL's Listing, Classification, and Recognition Services.
30. Voice over Internet Protocol (VoIP): Digital telephone packet technology that uses the internet for its transmission medium.
31. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
    a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
    b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
    c. Extra-Low Voltage (ELV): Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V (ac rms), 42 V (ac peak), or 60 V(dc).
    d. Low Voltage (LV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
    e. Medium Voltage (MV): Having electromotive force between any two conductors, or between a single conductor and ground, that is rated about 1 kV but not exceeding 69 kV.
    f. High Voltage: (1) (circuits) Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 69 kV but not exceeding 230 kV. (2) (safety) Having sufficient electromotive force to inflict bodily harm or injury.
32. Wire: In accordance with NIST NBS Circular 37 and IEEE standards, in the United States for the purpose of interstate commerce, the definition of "wire" is a slender rod or filament of drawn metal. A group of small wires used as a single wire is properly called a "stranded wire." A wire or stranded wire covered with insulation is properly called an "insulated wire" or a "single-conductor cable." Nevertheless, when the context indicates that the wire is insulated, the term "wire" will be understood to include the insulation.

1.3 COORDINATION – NOT USED

1.4 PREINSTALLATION MEETINGS

A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than 10 days after Notice to Proceed. Agenda topics include, but are not limited to, the following:

1. Electrical installation schedule.
2. Status of power system studies.
3. Value analysis proposals and requests for substitution of electrical equipment.
4. Utility work coordination and class of service requests.
5. Commissioning activities.

1.5 SEQUENCING

A. Conduct and submit results of power system studies before submitting product data and Shop Drawings for electrical equipment.

1.6 SCHEDULING – NOT USED

1.7 ACTION SUBMITTALS

A. Coordination Drawings for Structural Supports: Show coordination of structural supports for equipment and devices, including restraints and bracing for control of seismic and wind loads, with other systems, equipment, and structural supports in the vicinity.

B. Coordination Drawings for Ceiling Areas: Where indicated on drawings, provide reflected ceiling plan(s), supplemented by sections and other details, drawn to scale, in accordance with Section 013100 "Project Management and Coordination," on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which equipment and suspension systems will be attached.
3. Size and location of access panels on ceilings.
4. Elevation, size, and route of sprinkler piping.
5. Elevation, size, and route of plumbing piping.
6. Elevation, size, and route of ductwork.
7. Elevation, size, and route of cable tray.
8. Elevation, size, and route of conduit.
9. Elevation and size of wall-mounted and ceiling-mounted equipment.
10. Access panels.
11. Sprinklers.
12. Air inlets and outlets.
13. Control modules.
14. Luminaires.

15. Communications devices.
16. Speakers.
17. Security devices.
18. Fire-alarm devices.
19. Indicate clear dimensions for maintenance access in front of equipment.
20. Indicate dimensions of fully open access doors.

C. Coordination Drawings for Conduit Routing: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

D. Coordination Drawings for Large Equipment Indoor Installations:
1. Location plan, drawn to scale, showing heavy equipment or truck access paths to loading dock or other freight access into building. Indicate available width and height of doors or openings.
2. Floor plan for entry floor and floor where equipment is located, drawn to scale, showing heavy equipment access paths for maintenance and replacement, with the following items shown and coordinated with each other, based on input from installers of the items involved:
   a. Dimensioned concrete bases, outlines of equipment, conduit entries, and grounding equipment locations.
   b. If freight elevator must be used, indicate width and height of door and depth of car. Indicate if large equipment must be tipped to use elevator.
   c. Dimensioned working clearances and dedicated areas below and around electrical equipment where obstructions and tripping hazards are prohibited.
3. Reflected ceiling plans for entry floor and floor where equipment is located, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   a. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways and seismic bracing.
   b. Location of lighting fixtures, sprinkler piping and sprinklers, ducts and diffusers, and other obstructions, indicating available overhead clearance.
   c. Dimensioned working clearances and dedicated areas above and around electrical equipment where foreign systems and equipment are prohibited.

E. Coordination Drawings for Duct Banks:

1. Show duct profiles and coordination with other utilities and underground structures.
2. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.

1.8 INFORMATIONAL SUBMITTALS

A. Electrical Installation Schedule: At preconstruction meeting, and periodically thereafter as dates change, provide schedule for electrical installation Work to Owner and Architect including, but not limited to, milestone dates for the following activities:
1. Submission of power system studies.
2. Submission of specified coordination drawings.
3. Submission of action submittals specified in Division 26.
4. Orders placed for major electrical equipment.
5. Arrival of major electrical equipment on-site.
6. Preinstallation meetings specified in Division 26.
7. Utility service outages.
8. Utility service inspection and activation.
9. Mockup reviews.
10. Closing of walls and ceilings containing electrical Work.
11. System startup, testing, and commissioning activities for major electrical equipment.
12. System startup, testing, and commissioning activities for emergency lighting.
13. System startup, testing, and commissioning activities for automation systems (SCADA, BMS, lighting, HVAC, fire alarm, fire pump, etc.).
14. Pouring of concrete housekeeping pads for electrical equipment and testing of concrete samples.
15. Requests for special inspections.
16. Requests for inspections by authorities having jurisdiction.

B. Welding certificates.

C. Seismic Performance Certificates: Provide special certification for designated seismic systems as required to meet requirements specified in Section 018123 "Facility Seismic and Wind Criteria" for all designated seismic systems identified on the Drawings or in the Specifications.
1. Include the following information:
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

d. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

e. Equipment manufacturer's written certification for each designated active electrical seismic device and system, stating that it will remain operable following the basis-of-design seismic criteria specified in Section 018123 "Facility Seismic and Wind Criteria."

f. Equipment manufacturer's written certification that components with hazardous contents maintain containment following the basis-of-design seismic criteria specified in Section 018123 "Facility Seismic and Wind Criteria."

g. Evidence demonstrating compliance with these requirements for approval to authorities having jurisdiction after review and acceptance by qualified structural professional engineer.

D. Wind Performance Certificates: Provide special certification for systems and components designated on the Drawings or in the Specifications to be subject to high wind exposure and impact damage.

1. Include the following information:

a. Provide equipment manufacturer's written certification for each designated system and component, stating that it will remain in place and operable following the design wind event and comply with requirements of authorities having jurisdiction.

b. Certification must be based on ICC-ES or similar nationally recognized testing standard procedures acceptable to authorities having jurisdiction.

E. Qualification Statements:

1. For qualified regional manufacturer.
2. For structural professional engineer.
3. For electrical professional engineer.
4. For lighting professional engineer.
5. For EPM specialist.
6. For welder.
7. For ERMC-S-PVC raceway Installer.
8. For electrical power monitoring Installer.
9. For switchboard Installer.
10. For EVSE Installer.
11. For generator set Installer.
12. For lightning protection system Installer.

13. For power quality specialist.
14. For low-voltage electrical testing agency and on-site electrical testing supervisor.
15. For power-limited electrical testing agency and on-site power-limited testing supervisor.
16. For structural testing and inspecting agency.
17. For outdoor pole testing and inspecting agency.
18. For luminaire photometric testing laboratory.
19. For lighting testing and inspecting agency.

1.9 CLOSEOUT SUBMITTALS

A. Facility EMP Binders:
   1. Complete Set: On USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
   2. Volumes 2 and 8: Reproducible hardcopy on archival quality, 28 lb (105 GSM), acid-free, bond paper.

B. Operation and Maintenance Data:
   1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device used in the project.
   2. Include the following information:
      a. Manufacturer's operating specifications.
      b. User's guides for software and hardware.
      c. Schedule of maintenance material items recommended to be stored at the Project site.
      d. Detailed instructions covering operation under both normal and abnormal conditions.
      e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
      f. List of load-current and overload-relay heaters with related motor nameplate data.
      g. List of lamp types and photoelectric relays used on the Project, with ANSI and manufacturers' codes.
      h. Manufacturer's instructions for setting field-adjustable components.
      i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
      j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
      k. Exterior pole inspection and repair procedures.

C. Software and Firmware Operational Documentation: Provide software and firmware operational documentation in Facility EPM Binders, including the following:
   1. Software operating and upgrade manuals.
   2. Names, versions, and website addresses for locations of installed software.
   3. Device address list.
   4. Printout of software application and graphic screens.
   5. Testing and adjusting of panic and emergency power features.
   6. For lighting controls, include the following:
      a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
      b. Operation of adjustable zone controls.

D. Software:
   1. Program Software Backup: Provide USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
   2. Provide to Owner upgrades and unrestricted licenses for installed and backup software, including operating systems and programming tools required for operation and maintenance.

1.10 MOCKUPS – NOT USED

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION – NOT USED

END OF SECTION 260010

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SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Thermoplastic-insulated wire.
   2. Thermoset-insulated wire.
   3. Metallic sheathed cable.
   4. Connectors and splices.

B. Related Requirements:
   1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
   2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
   3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
   4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
   5. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.
   6. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
   7. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers, supports, and concrete bases referenced by this Section.
   8. Section 260533.13 "Conduits for Electrical Systems" specifies installation of raceways referenced by this Section.
   9. Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling" specifies installation of sleeves and sleeve seals referenced by this Section.
   10. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.

1.2 DEFINITIONS

A. NICET: National Institute for Certification in Engineering Technologies; a division of the National Society of Professional Engineers (NSPE).

B. RoHS: Restriction of Hazardous Substances.

C. VFC: Variable-Frequency controller.

1.3 ACTION SUBMITTALS

A. Product Schedule: Indicate type, use, location, and termination locations.

B. Product Data: For each type of product.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Field Reports:

1. Field reports for infrared scanning.

1.5 QUALIFICATIONS – NOT USED

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 THERMOPLASTIC-INSULATED WIRE

A. Description: Thermoplastic-insulated wire for use in accordance with Article 310 of NFPA 70.

B. UL ZLGR – Type THHN Insulated Wire:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Alpha Wire Company.
   b. Cerro Wire LLC.
   c. Okonite Company (The).
   d. Southwire Company.
   e. Service Wire Company.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
3. Standard Features:
   a. Referenced Standard: Article 310 of NFPA 70.
   b. Insulation Voltage Rating: 600 V.
   c. Insulation Temperature Rating: 90 deg C.
   d. Conductor Material: Copper.
   e. Conductor Size: As indicated on the Drawings.

1) Minimum Conductor Size: 12 AWG.

4. Other Available Features Required by the Project:
   a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
   b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
   c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
   d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
   e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
   f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
   g. Marked "VW-1," indicating compliance with special vertical flame test.
   h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

C. UL ZLGR - Type THHW Insulated Wire
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Alpha Wire Company.
      b. Cerro Wire LLC.
      c. Okonite Company (The).
      d. Southwire Company.
      e. Service Wire Company
   2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
   3. Standard Features:
      a. Referenced Standard: Article 310 of NFPA 70.
      b. Insulation Voltage Rating: 600 V.
      c. Insulation Temperature Rating: 90 deg C.
      d. Conductor Material: Copper.
      e. Conductor Size: As indicated on the Drawings.
         1) Minimum Conductor Size: 12 AWG.
   4. Other Available Features Required by the Project:
      a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.

b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
g. Marked "VW-1," indicating compliance with special vertical flame test.
h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

D. UL ZLGR - Type THW Insulated Wire:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Alpha Wire Company.
b. Cerro Wire LLC.
c. Okonite Company (The).
d. Southwire Company.
e. Service Wire Company.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
3. Standard Features:
a. Referenced Standard: Article 310 of NFPA 70.
b. Insulation Voltage Rating: 600 V.
c. Insulation Temperature Rating: 90 deg C.
d. Conductor Material: Copper.
e. Conductor Size: As indicated on the Drawings.
1) Minimum Conductor Size: 12 AWG
4. Other Available Features Required by the Project:
a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.

e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
g. Marked "VW-1," indicating compliance with special vertical flame test.
h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

E. UL ZLGR - Type THW-2 Insulated Wire:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Alpha Wire Company.
b. Cerro Wire LLC.
c. Okonite Company (The).
d. Southwire Company.
e. Service Wire Company.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
3. Standard Features:
a. Referenced Standard: Article 310 of NFPA 70.
b. Insulation Voltage Rating: 600 V.
c. Insulation Temperature Rating: 90 deg C.
d. Conductor Material: Copper.
e. Conductor Size: As indicated on the Drawings.
1) Minimum Conductor Size: 12 AWG.
4. Other Available Features Required by the Project:
a. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
b. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
c. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
d. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
e. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
f. Marked "VW-1," indicating compliance with special vertical flame test.
g. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

F. UL ZLGR - Type THWN Insulated Wire:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Alpha Wire Company.
      b. Cerro Wire LLC.
      c. Okonite Company (The).
      d. Southwire Company.
      e. Service Wire Company.
   2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
   3. Standard Features:
      a. Referenced Standard: Article 310 of NFPA 70.
      b. Insulation Voltage Rating: 600 V.
      c. Insulation Temperature Rating: 75 deg C.
      d. Conductor Material: Copper.
      e. Conductor Size: As indicated on the Drawings.
         1) Minimum Conductor Size: 12 AWG.
   4. Other Available Features Required by the Project:
      a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
      b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
      c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
      d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
      e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
      f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
      g. Marked "VW-1," indicating compliance with special vertical flame test.
      h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

G. UL ZLGR - Type THWN-2 Insulated Wire:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Alpha Wire Company.

b. Cerro Wire LLC.
c. Okonite Company (The).
d. Southwire Company.
e. Service Wire Company.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Thermoplastic-Insulated Wire: UL CCN ZLGR, including UL 83.
3. Standard Features:
   a. Referenced Standard: Article 310 of NFPA 70.
   b. Insulation Voltage Rating: 600 V.
   c. Insulation Temperature Rating: 90 deg C.
   d. Conductor Material: Copper.
   e. Conductor Size: As indicated on the Drawings.
      1) Minimum Conductor Size: 12 AWG.
4. Other Available Features Required by the Project:
   a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
   b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
   c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
   d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
   e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
   f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
   g. Marked "VW-1," indicating compliance with special vertical flame test.
   h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.

H. UL ZKST - Type XHH Insulated Wire:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Alpha Wire Company.
   b. Cerro Wire LLC.
   c. Okonite Company (The).
   d. Southwire Company.
   e. Service Wire Company.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
    a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
3. Standard Features:
    a. Referenced Standard: Article 310 of NFPA 70.
    b. Insulation Voltage Rating: 600 V.
    c. Insulation Temperature Rating: 90 deg C.
    d. Conductor Material: Copper.
    e. Conductor Size: As indicated on the Drawings.
        1) Minimum Conductor Size: 12 AWG.
4. Other Available Features Required by the Project:
    a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
    b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
    c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
    d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
    e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
    f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
    g. Marked "VW-1," indicating compliance with special vertical flame test.
    h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
    i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
        1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

I. UL ZKST - Type XHHW Insulated Wire:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Alpha Wire Company.
    b. Cerro Wire LLC.
    c. Okonite Company (The).
    d. Southwire Company.
    e. Service Wire Company.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
    a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
3. Standard Features:
    a. Referenced Standard: Article 310 of NFPA 70.
    b. Insulation Voltage Rating: 600 V.
    c. Insulation Temperature Rating: 75 deg C for wet locations, 90 deg C for dry and damp locations.
    d. Conductor Material: Copper.
    e. Conductor Size: As indicated on the Drawings.
        1) Minimum Conductor Size: 12 AWG.
4. Other Available Features Required by the Project:
    a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
    b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
    c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
    d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
    e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
    f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
    g. Marked "VW-1," indicating compliance with special vertical flame test.
    h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
    i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
        1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

J. UL ZKST - Type XHHW-2 Insulated Wire:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Alpha Wire Company.
    b. Cerro Wire LLC.
    c. Okonite Company (The).
    d. Southwire Company.

e. Service Wire Company.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Thermoset-Insulated Wire: UL CCN ZKST, including UL 44.
3. Standard Features:
   a. Referenced Standard: Article 310 of NFPA 70.
   b. Insulation Voltage Rating: 600 V.
   c. Insulation Temperature Rating: 90 deg C.
   d. Conductor Material: Copper.
   e. Conductor Size: As indicated on the Drawings.
      1) Minimum Conductor Size: 12 AWG.
4. Other Available Features Required by the Project:
   a. Marked "Cable Tray Use" or "CT," indicating compliance with vertical-tray cable flame test.
   b. Marked "Sunlight Resistant" or "SR," indicating compliance with artificial weathering test.
   c. Marked "Oil Resistant I" or "PR I," indicating 60 deg C oil resistance.
   d. Marked "Oil Resistant II" or "PR II," indicating 75 deg C oil resistance.
   e. Marked "Gasoline and Oil Resistant I" or "GR I," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 60 deg C.
   f. Marked "Gasoline and Oil Resistant II" or "GR II," indicating suitable for exposure to gasoline at 23 deg C and exposure to mineral oil at 75 deg C.
   g. Marked "VW-1," indicating compliance with special vertical flame test.
   h. Marked "ST1," indicating compliance with UL 1685 flame and smoke test.
   i. Marked "ST1-HF," indicating that combustible materials are halogen-free in accordance with UL Subject 2885.
      1) Marked "ST1-LSHF," indicating that combustible materials are low smoke when also tested in accordance with IEC 61034-2.

2.3 NONMETALLIC UNDERGROUND CONDUIT WITH CONDUCTORS – NOT USED

2.4 METALLIC SHEATHED CABLE – NOT USED

2.5 PHOTOVOLTAIC SINGLE-CONDUCTOR CABLE – NOT USED

2.6 NONMETALLIC JACKETED CABLE – NOT USED

2.7 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
   1. Material: Copper.
   2. Type: One hole with standard barrels.
   3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:
   1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits:
   1. Material: Copper.
      a. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
      b. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

E. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway.

F. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway, except for isolated power system conductors. Type XHHW/XHHW-2, shall be used for all isolated power system branch circuits.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.

3.3 INSTALLATION OF LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Temporary Electric Power Work: NECA NEIS 200.
5. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
6. Work in Confined Spaces: NFPA 350.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
8. Installation of Type AC and Type MC Cables: NECA NEIS 120.
9. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
2. Complete raceway installation between conductor and cable termination points prior to pulling conductors and cables.
3. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
4. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
5. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
6. Provide support for cables.
7. Complete cable tray systems installation prior to installing conductors and cables.
8. Connections:
    a. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

b. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   1) Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

9. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch (150 mm) of slack.

D. Interfaces with Other Work:
1. Identification:
   a. Identify and color-code conductors and cables.
   b. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.
2. Sleeves and Sleeve Seals: Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies.
3. Firestopping: Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.4 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:
1. Owner will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage a factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
3. Perform each of the following visual and electrical tests:
   a. Inspect exposed sections of conductor and cable for physical damage and correct connection in accordance with the single-line diagram.
   b. Test bolted connections for high resistance using one or more of the following:
      1) A low-resistance ohmmeter.
      2) Calibrated torque wrench.
      3) Thermographic survey.

c. Inspect compression-applied connectors for correct cable match and indentation.
d. Inspect for correct identification.
e. Inspect cable jacket and condition.
f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

C. Nonconforming Work:
1. Wire or cable assembly will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports to record the following:
1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

3.5 MAINTENANCE

A. Infrared Scanning of Splices: Two months after Substantial Completion, perform infrared scan of splices, joints, and connections in conductors 3 AWG and larger. Remove covers so splices, joints, and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison. Correct deficiencies determined during the scan.
1. Follow-On Infrared Scanning: Perform follow-up infrared scan of splices at 11 months after Substantial Completion.
2. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
3. Field Reports for Infrared Scanning: Prepare certified report that identifies cables splices checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 260519

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connectors.
7. Grounding and bonding busbars.
8. Signal reference grids.
9. Grounding (earthing) electrodes.
10. Grounding electrode enclosures.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 264113 "Lightning Protection for Structures" specifies bonding of lightning protection grounding electrodes to facility grounding electrodes.
5. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
   a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.

b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.

c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.

B. Shop Drawings: Prepare and submit the following:

1. Plans showing dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:

a. Grounding electrode access enclosures.

b. Grounding electrodes.

c. Grounding arrangements and connections for separately derived systems.

C. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in “Field Quality Control” Article, including the following:

1. Test wells.

2. Ground rods.

3. Ground rings.

B. Qualification Data: For testing agency and testing agency’s field supervisor.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:

a. Plans showing as-built, dimensioned locations of grounding features described in "Field Quality Control for Grounding and Bonding" Article, including the following:

1) Grounding electrode access enclosures.

2) Grounding electrodes.

3) Grounding arrangements and connections for separately derived systems.

4) Ground rings.

5) Test wells.

b. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems based on NETA MTS.

1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.

2) Include recommended testing intervals.

1.5 QUALIFICATIONS – NOT USED

1.6 SERVICE CONDITIONS FOR ELECTRICAL EQUIPMENT

A. Soil Resistivity: Grounding (earthing) Work on the Project must account for soil resistivity conditions specified in Section 018116 "Facility Environmental Requirements."

B. Electrical and ICT Equipment Grounding (Earthing): Do not exceed 25 Ω resistance value resistance to ground (earth).

1. Contact Architect for resolution if 25 Ω specified resistance to ground (earth) is not attained after complying with prescriptive requirements in Article 250 of NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and requirements.

2.2 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. Standard Features: 600 V, THHN/THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Isolated Equipment Grounding Conductor:

1. Standard Features: 600 V, THHN/THWN-2, copper wire or cable, green color with one or more yellow stripes, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Standard Features: Complying with one or more of the following:

a. Soft or Annealed Copper Wire: ASTM B3.

b. Concentric-Lay Stranded Copper Conductor: ASTM B8.

c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.

d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

e. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.

f. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.

g. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

h. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6mm) thick.

2.3 GROUNDING AND BONDING CONNECTORS

A. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy
   b. Thomas & Betts
   c. Illsco
   d. Panduit
   e. RS Components
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
   b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
4. Standard Features: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.

B. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy.
   b. Thomas & Betts
   c. Illsco
   d. Panduit
   e. RS Components
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

4. Standard Features: Mechanical-type, copper rated for direct burial terminal with set screw.

C. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy.
   b. Thomas & Betts
   c. Illsco
   d. Panduit
   e. RS Components
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
   b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
4. Standard Features: Bolts that surround cable and bond to cable under compression when nut is tightened.
   a. Copper.

D. UL KDER - Signal Reference Grid Grounding and Bonding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy.
   b. Thomas & Betts
   c. Illsco
   d. Panduit
   e. RS Components
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

4. Standard Features: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

2.4 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.

B. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy.
   b. Thomas & Betts
   c. Illsco
   d. Panduit
   e. RS Components
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
3. Standard Features: Zinc-alloy one-piece construction; six terminating points; gangable.

C. UL KDSH - Two-Piece Intersystem Bonding Bridge Grounding:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy.
   b. Thomas & Betts
   c. Illsco
   d. Panduit
   e. RS Components
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

3. Standard Features: Copper body and polycarbonate cover; four terminating points.

2.5 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding devices that serve as common connection for multiple grounding and bonding conductors.

B. UL KDER - Equipment Room Grounding and Bonding Busbar:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy.
   b. Thomas & Betts
   c. Illsco
   d. Panduit
   e. RS Components
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
4. Standard Features:
   a. Bus: Rectangular bar of annealed copper.
   b. Mounting Stand-Off Insulators: Lexan or PVC.
      1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.
5. Other Available Features Required by the Project:
   a. Dimensions: 1/4 by 4 inch (6.3 by 100 mm) in cross section; length as indicated on the Drawings.
   b. Predrilled Hole Pattern: 9/32 inch (7.14 mm) holes spaced 1-1/8 inch (28 mm) apart.
   c. Mounting Hardware: Stand-off brackets that provide 2 inch (50 mm) clearance to access rear of bus. Brackets and bolts must be stainless steel.

C. UL KDER - Rack and Cabinet Bonding Busbar:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Burndy.

b. Thomas & Betts
c. Illsco
d. Panduit
e. RS Components

2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
4. Standard Features:
   a. Bus: Rectangular bar of hard-drawn solid copper.
   b. Horizontal Mounting Dimensions: Designed for mounting in 19 inch (483 mm) wide equipment racks or cabinets.
   c. Vertical Mounting Dimensions: Designed for mounting in 72 inch (1827 mm) high equipment racks or cabinets.
   d. Predrilled Hole Pattern: Accepts connectors for grounding and bonding conductor sizes 14 AWG to 2/0 AWG.
   e. Mounting Hardware: Stainless steel or copper-plated, for attachment to rack.

2.6 SIGNAL REFERENCE GRIDS

A. Description: Means for providing low-impedance path to ground over a large area, approximating an equipotential plan, while simultaneously mitigating large current spikes from faults or lightning.

B. UL KDER - Mesh-Type Signal Reference Grid:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. nVent ERICO
   b. Harger
   c. aIIG Fabrication, Ltd.
   d. Mayday Grounding, Inc.
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
4. Standard Features: Conductive metal wire mesh for field-fabrication of grid.

a. Wire Size: 6 AWG.
b. Wire Material: Copper.
c. Spacing: 24 inch (610 mm).
d. Welded or brazed intersections.

2.7 GROUNDING (EARTHING) ELECTRODES

A. UL KDER - Rod Electrode:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. nVent ERICO
   b. American Wire Group
   c. TMD Holdings, LLC
   d. Colonial Teltek
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
4. Standard Features: Copper-clad steel; 3/4 inch by 10 ft (19 mm by 3 m).

B. UL KDER - Plate Electrode:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. nVent ERICO
   b. Harger
   c. TMD Holdings, LLC
   d. American Grounding & Lightning Protection
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
4. Standard Features: 1/4 inch (6 mm) thick, hot-dip galvanized.

2.8 GROUNDING ELECTRODE ENCLOSURES

A. Description: Enclosures designed to protect grounding electrodes from damage while providing access for inspection and testing of the grounding system.

B. Grounding Electrode Access Well Enclosure:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. nVent ERICO
   b. Panduit
   c. Illsco
   d. Thomas & Betts
2. Source Limitations: Obtain products from single manufacturer.
3. Standard Features:
   a. Well Material: Concrete
   b. Cover Material: Cast iron.
   c. Cover Strength: Driveway use.
4. Other Available Features Required by the Project:
   a. Round:
      1) Nominal Diameter: 12 inch (300 mm).
      2) Nominal Height: 12 inch (300 mm).
      3) Slotted sides for installation after grounding connections made.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.

B. Inspect test results of grounding system measured at point of electrical service equipment connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GROUNDING AND BONDING PRODUCTS

A. Grounding and Bonding Conductors:
   1. Provide solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
   2. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
   3. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch (6 mm) in diameter.
   4. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.

5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch (41 mm) wide and 1/16 inch (1.6 mm) thick.
6. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Underground Grounding Conductors: Install bare tinned-copper conductor, 2/0 AWG minimum.

B. Grounding and Bonding Connectors:
1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Grounding and Bonding Busbars: Provide in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated on the Drawings.

D. Substation Signal Reference Grid:
1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with IEEE C2.
a. Install 6 AWG bonding conductors below grade in a grid pattern on 2 ft (600 mm) centers. Bond grid conductors with exothermic welds where they cross each other.
b. Grid must fill entire area inside equipment yard fence, and extend minimum 6.5 ft (2 m) outside fence, so someone walking or running outside yard may not touch fence or open gate without first stepping inside grid.
c. Bond each metal fence post and gate post to at least two grid conductors.
d. Inside grid, bond equipment reinforcing steel inside bases and sidewalks to at least two grid conductors.
e. Bond underground metal pipe and conduit passing under grid to nearest grid conductor at both ends.

3.3 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR COMMUNICATIONS

A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."

3.4 SELECTION OF GROUNDING AND BONDING PRODUCTS FOR TOWERS AND ANTENNAS – NOT USED

3.5 INSTALLATION OF GROUNDING AND BONDING

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Communications Work: BICSI N1.
6. Work in ITE Rooms: NFPA 75.
7. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
8. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
9. Work in Confined Spaces: NFPA 350.
10. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
11. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
12. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Grounding and Bonding Conductors:
   a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
   b. Underground Grounding Conductors:
      1) Bury at least 30 inch (750 mm) below grade.
      2) Duct-Bank Grounding Conductor: Bury 12 inch (300 mm) above duct bank when indicated as part of duct-bank installation.
2. Grounding and Bonding Connectors: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
   a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
   b. Make connections with clean, bare metal at points of contact.
   c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
   d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.

e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.

2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.

g. Grounding and Bonding for Piping:

1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.

3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft (18 m) apart.

3. Grounding and Bonding Busbars:

a. Install busbar horizontally, on insulated spacers 2 inch (50 mm) minimum from wall, 6 inch (150 mm) above finished floor unless otherwise indicated.

b. Where busbars are indicated on both sides of doorways, route bonding conductor up to top of door frame, across top of doorway, and down; connect to continuation of horizontal busbar.

4. Electrodes:

a. Ground Rods: Drive rods until tops are 2 inch (50 mm) below finished floor or final grade unless otherwise indicated.
   1) Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
   2) Use exothermic welds for below-grade connections.

b. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to service grounding electrode conductor.

c. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least 12 inch (300 mm) deep, with cover.
   1) Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

d. Ring Electrode: Install grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around perimeter of building.
   1) Install tinned-copper conductor not less than 2/0 AWG for ring electrode and for taps to building steel.
   2) Bury ring electrode not less than 24 inch (600 mm) from building's foundation.

e. Concrete-Encased Electrode (Ufer Ground):
   1) Fabricate in accordance with NFPA 70; use minimum of 20 ft (6 m) of bare copper conductor not smaller than 4 AWG.
      a) If concrete foundation is less than 20 ft (6 m) long, coil excess conductor within base of foundation.
      b) Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
   2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft (6.0 m) long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.

5. Grounding at Service:

a. Equipment grounding conductors and grounding electrode conductors must be connected to ground busbar. Install main bonding jumper between neutral and ground buses.

6. Grounding Separately Derived Systems:
   a. Permanent Generators: Install grounding electrode(s) at location of permanent generators having switched neutral connections. Electrode must be connected to equipment grounding conductor and to frame of generator.
7. Grounding Underground Distribution System Components:
   a. Duct-Bank Grounding Conductor: Bury 12 inch (300 mm) above duct bank when indicated as part of duct-bank installation.
   b. Comply with IEEE C2 grounding requirements.
   c. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch (50 mm) above to 6 inch (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
   d. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.
   e. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than 6 inch (150 mm) from foundation.
8. Equipment Grounding and Bonding:
   a. Install insulated equipment grounding conductors with feeders and branch circuits.

b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   1) Feeders and branch circuits.
   2) Lighting circuits.
   3) Receptacle circuits.
   4) Single-phase motor and appliance branch circuits.
   5) Three-phase motor and appliance branch circuits.
   6) Flexible raceway runs.
   7) Armored and metal-clad cable runs.
   8) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
   9) X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

d. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

e. Isolated Grounding Receptacle Circuits: Install insulated equipment grounding conductor connected to receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.

f. Isolated Equipment Enclosure Circuits: For designated equipment supplied by branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.

g. Poles Supporting Outdoor Lighting Fixtures: Bond insulated equipment grounding conductor to equipment grounding terminal inside pole base.

h. Metallic Fences: Comply with requirements of IEEE C2.

1) Grounding Conductor: Bare copper, not less than **8 AWG**.
2) Gates: Must be bonded to grounding conductor with flexible bonding jumper.
3) Barbed Wire: Strands must be bonded to grounding conductor.

3.6 FIELD QUALITY CONTROL FOR GROUNDING AND BONDING

A. Administrant for Electrical Power Tests and Inspections:
1. Owner will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Acceptance Testing Preparation:
1. Prepare test and inspection reports.

C. Field tests and inspections must be witnessed by authorities having jurisdiction.

D. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal**,** at ground test wells, and at individual ground rods. Make tests at ground rods before conductors are connected.
a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and

key to record of tests and observations. Include number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

E. Nonconforming Work:
   1. Grounding system will be considered defective if it does not pass tests and inspections.
   2. Remove and replace defective components and retest.

F. Collect, assemble, and submit test and inspection reports.
   1. Report measured ground resistances that exceed the following values:
      a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω.
      b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω.
      c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 Ω.
      d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 Ω.
      e. Substations and Pad-Mounted Equipment: 5 Ω.
      f. Manhole Grounds: 10 Ω.

3.7 PROTECTION

A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260526

SECTION 260529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Aluminum slotted support systems.
3. Conduit and cable support devices.
4. Support for conductors in vertical conduit.
5. Structural steel for fabricated supports and restraints.
6. Mounting, anchoring, and attachment components, including power-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
7. Installation of fabricated metal equipment support assemblies.
8. Installation of concrete bases.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 033000 "Cast-in-Place Concrete" specifies concrete materials, reinforcement, and placement requirements referenced by this Section.
5. Section 055000 "Metal Fabrications" specifies site-fabricated metal supports referenced by this Section.
6. Section 099113 "Exterior Painting", Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" specify cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal referenced by this Section.
7. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies vibration controls, seismic restraints, and wind restraints referenced by this Section.

1.2 DELEGATED DESIGN SERVICES

A. Delegated Design Professionals: Engage qualified structural professional engineer to design hangers and supports for electrical systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
   a. Slotted support systems, hardware, and accessories.
   b. Clamps.
   c. Hangers.
   d. Sockets.
   e. Eye nuts.
   f. Fasteners.
   g. Anchors.
   h. Saddles.
   i. Brackets.
2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated Design Submittals: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 REGULATORY AGENCY APPROVALS

A. Delegated design submittals and shop drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.

1.6 QUALIFICATIONS

A. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind controls, equipment hangers and supports, and concrete foundations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Prepare design calculations in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 018123 "Facility Seismic and Wind Criteria."

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

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT SYSTEMS

A. Steel Slotted Support Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
   b. Atkore Unistrut
   c. Gripple
   d. Robroy Industries
2. Standard Features: Preformed steel channels and angles with minimum 13/32 inch (10 mm) diameter holes at a maximum of 8 inch (200 mm) on center in at least one surface.
   a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
   b. Material for Channel, Fittings, and Accessories: Galvanized steel.
   c. Channel Width: Selected for applicable load criteria, such as 1-5/8 inch (41.25 mm), 1-1/4 inch (31.75 mm), and 13/16 inch (20.64 mm).
   d. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.

g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Aluminum Slotted Support Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
   b. Atkore Unistrut
2. Standard Features: Extruded-aluminum channels and angles with minimum 13/32 inch (10 mm) diameter holes at a maximum of 8 inch (200 mm) on center in at least one surface.
   a. Referenced Standard: MFMA-4 factory-fabricated components for field assembly.
   b. Channel Material: 6063-T5 aluminum alloy.
   c. Fittings and Accessories Material: 5052-H32 aluminum alloy.
   a. Channel Width: Selected for applicable load criteria, such as 1-5/8 inch (41.25 mm), 1-1/4 inch (31.75 mm), and 13/16 inch (20.64 mm).
   b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   d. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Conduit and Cable Support Devices:

1. Standard Features: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit:

1. Standard Features: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.

E. Structural Steel for Fabricated Supports and Restraints:

1. Standard Features: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

2.3 MOUNTING, ANCHORING, AND ATTACHMENT COMPONENTS

A. Powder-Actuated Fasteners:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Simpson Strong-Tie
b. Nail Gun Depot
c. Benefast
d. NEFCO
e. Fastening Specialists, LLC.

2. Standard Features: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hilti
   b. Simpson Strong-Tie
   c. Dewalt
2. Standard Features: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

C. Concrete Inserts:

1. Standard Features: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

D. Clamps for Attachment to Steel Structural Elements:

1. Standard Features: MSS SP-58 units are suitable for attached structural element.

E. Through Bolts:

1. Standard Features: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325 (Grade A325M).

F. Toggle Bolts:

1. Standard Features: All steel springhead type.

G. Hanger Rods:

1. Standard Features: Threaded steel.

PART 3 - EXECUTION

3.1 SELECTION OF HANGERS AND SUPPORTS

A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch (6 mm) in diameter.

B. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

C. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2 inch (38 mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Hot Work: NFPA 51B.
3. Work in Confined Spaces: NFPA 350.
4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
5. Installation of Steel Conduit: NECA NEIS 101.
6. Installation of Aluminum Conduit: NECA NEIS 102.
7. Installation of Metal Cable Tray Systems: NECA NEIS 105.
8. Installation of Nonmetallic Cable Tray Systems: NECA NEIS 111.
9. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT, IMC, and ERMC may be supported by openings through structure members, in accordance with NFPA 70.
2. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus 200 lb (90 kg).
3. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   a. To Wood: Fasten with lag screws or through bolts.
   b. To New Concrete: Bolt to concrete inserts.

c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.

d. To Existing Concrete: Expansion anchor fasteners.

e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inch (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inch (100 mm) thick.

f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.

g. To Light Steel: Sheet metal screws.

h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

4. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

D. Interfaces with Other Work:

1. Provide vibration and seismic controls with hangers and supports.

2. Touchup Finishes:

a. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1) Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

b. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

c. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

3. Installation of Fabricated Metal Supports:

a. Provide site-fabricated metal supports.

b. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

c. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.

4. Installation of Concrete Bases:

a. Provide concrete bases of dimensions indicated, but not less than 4 inch (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

b. Use 3000 psi (20.7 MPa), 28-day compressive-strength concrete.

c. Anchor equipment to concrete base as follows:

1) Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

2) Install anchor bolts to elevations required for proper attachment to supported equipment.

3) Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION 260529

SECTION 260533.13

CONDUITS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT duct raceways and elbows.
2. Type ERMC duct raceways, elbows, couplings, and nipples.
3. Type FMC duct raceways.
4. Type IMC duct raceways.
5. Type LFMC duct raceways.
6. Type LFNC duct raceways.
7. Type PVC duct raceways and fittings.
8. Fittings for conduit, tubing, and cable.
9. Joint compounds.
10. Solvent cements.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies firestopping referenced by this Section.
5. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
6. Section 260529 "Hangers and Supports for Electrical Systems" specifies conduit hangers and supports referenced by this Section.
7. Section 260543 "Underground Ducts and Raceways for Electrical Systems" specifies exterior duct banks, manholes, and underground utility construction.
8. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electrical Raceway Types:

1. EMT: Electrical metallic tubing.
2. EMT-S: Steel electrical metallic tubing.
3. ERMC: Electrical rigid metal conduit.
4. ERMC-S: Steel electrical rigid metal conduit.
5. ERMC-S-G: Galvanized-steel electrical rigid metal conduit.
6. FMC: Flexible metal conduit.
7. FMC-S: Steel flexible metal conduit.
8. FNMC: Flexible nonmetallic conduit. See "LFNC."
9. IMC: Steel electrical intermediate metal conduit.
10. LFMC: Liquidtight flexible metal conduit.
11. LFMC-S: Steel liquidtight flexible metal conduit.
12. LFNC: Liquidtight flexible nonmetallic conduit.
13. LFNC-A: Layered (Type A) liquidtight flexible nonmetallic conduit.
14. LFNC-B: Integral (Type B) liquidtight flexible nonmetallic conduit.
15. LFNC-C: Corrugated (Type C) liquidtight flexible nonmetallic conduit.
16. PVC: Rigid PVC conduit.
17. PVC-40: Schedule 40 rigid PVC conduit.
18. PVC-80: Schedule 80 rigid PVC Conduit.
19. PVC-A: Type A rigid PVC concrete-encased conduit.
20. PVC-EB: Type EB rigid PVC concrete-encased underground conduit.

B. Definitions:

1. Conduit: A structure containing one or more duct raceways.
2. Direct Buried: Installed underground without encasement in concrete or other protective material.
3. Duct Bank: An arrangement of conduit providing one or more continuous duct raceways between two points.
4. Duct Raceway: A single enclosed raceway for conductors or cable.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Field quality-control reports.

C. Samples: For wireways and for each color and texture specified, 12 inches (300 mm) long.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Seismic Qualification Data: Certificates for conduit racks and their mounting provisions from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
3. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

C. Source quality-control reports.

1.5 QUALIFICATIONS – NOT USED

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 TYPE EMT DUCT RACEWAYS AND ELBOWS

A. UL FJMX - Steel Electrical Metal Tubing (EMT-S) and Elbows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Wheatland Tube
   b. Republic Conduit
   c. Western Tube
   d. Zekelman Industries
   e. Atkore
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN FJMX; including UL 797.
3. Standard Features:
   a. Material: Steel.
   b. Exterior Coating: Zinc.
   c. Interior Coating: Zinc.
   d. Minimum Trade Size: Metric designator 21 (trade size 3/4).
4. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.

2.3 TYPE ENT DUCT RACEWAYS AND FITTINGS – NOT USED

2.4 TYPE HDPE AND TYPE EPEC DUCT RACEWAYS AND FITTINGS – NOT USED

2.5 TYPE ERMC DUCT RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. UL DYIX - Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anamet Electrical
   b. Nucor Tubular Products
   c. Southwire
   d. Western Tube
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DYIX; including UL 6.
3. Standard Features:
   a. Exterior Coating: Zinc.
   b. Interior Coating: Zinc.
   c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
4. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.

2.6 TYPE FMC DUCT RACEWAYS

A. UL DXUZ - Steel Flexible Metal Conduit (FMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
   b. Anamet Electrical
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DXUZ; including UL 1.
3. Standard Features:
   a. Material: Steel.
   b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
4. Other Available Features Required by the Project:

a. Colors: As indicated on the Drawings.

2.7 TYPE FMT DUCT RACEWAYS – NOT USED

2.8 TYPE IMC DUCT RACEWAYS

A. UL DYBY - Steel Intermediate Metal Conduit (IMC):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
   b. Anamet Electrical
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DYBY; including UL 1242.
3. Standard Features:
   a. Exterior Coating: Zinc
   b. Interior Coating: Zinc.
   c. Minimum Trade Size: Metric designator 21 (trade size 3/4).
4. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.

2.9 TYPE LFMC DUCT RACEWAYS

A. UL DXHR - Steel Liquidtight Flexible Metal Conduit (LFMC-S):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
   b. Anamet Electrical
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DXHR; including UL 360.
3. Standard Features:
   a. Material: Steel.
   b. Minimum Trade Size: **Metric designator 21 (trade size 3/4)**.
4. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.
5. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.

2.10 TYPE LFNC DUCT RACEWAYS

A. UL DXOQ - Layered (Type A) Liquidtight Flexible Nonmetallic Conduit (LFNC-A):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
   b. Anamet Electrical
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DXOQ; including UL 1660.
3. Standard Features:
   a. Type A conduit with smooth seamless inner core and cover bonded together with one or more reinforcement layers between core and cover.
   b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   c. Markings: 90 deg C dry.
4. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.

B. UL DXOQ - Integral (Type B) Liquidtight Flexible Nonmetallic Conduit (LFNC-B):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DXOQ; including UL 1660.
3. Standard Features:
   a. Type B conduit with smooth inner surface with integral reinforcement within conduit wall.
   b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   c. Markings: 90 deg C dry.
4. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.

C. UL DXOQ - Corrugated (Type C) Liquidtight Flexible Nonmetallic Conduit (LFNC-C):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. ABB

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DXOQ; including UL 1660.
3. Standard Features:
   a. Type C conduit with corrugated internal and external surfaces without integral reinforcement within conduit wall.
   b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   c. Markings: 90 deg C dry.
4. Other Available Features Required by the Project:
   a. Colors: As indicated on the Drawings.

2.11 TYPE PVC DUCT RACEWAYS AND FITTINGS

A. UL DZYR - Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DZYR; including UL 651.
3. Standard Features:
   a. Dimensional Specifications: Schedule 40.
   b. Minimum Trade Size: Metric designator 21 (trade size 3/4).
   c. Markings: For use with maximum 90 deg C wire.

B. UL DZYR - Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DZYR; including UL 651.
3. Standard Features:
   a. Dimensional Specifications: Type A.

b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

C. UL DZYR - Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DZYR; including UL 651.
3. Standard Features:
   a. Dimensional Specifications: Type EB.
   b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.12 TYPE RTRC DUCT RACEWAYS AND FITTINGS – NOT USED

2.13 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. UL DWTT - Fittings for Type IMC and Type PVC Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Wheatland Tube
   b. Thomas & Betts
   c. CANTEX
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DWTT; including UL 514B.
3. Standard Features:
   a. Material: Steel.
   b. Coupling Method: Compression coupling
   c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

B. UL FKAV - Fittings for Type EMT Duct Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Wheatland Tube
   b. EVT Electrical
   c. Kaiphone

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN FKAV; including UL 514B.
3. Standard Features:
   a. Material: Steel.
   b. Coupling Method: Compression coupling.
   c. Expansion and Deflection Fittings: UL 651 with flexible bonding jumper.

C. UL ILNR - Fittings for Type FMC Duct Raceways:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper/Crouse-Hinds
   b. Thomas & Betts
   c. OZ Gedney Co.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN ILNR; including UL 514B.

D. UL DXAS - Fittings for Type LFMC and Type LFNC Duct Raceways:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. AFC
   b. Electri-Flex Company
   c. Anaconda Sealtite
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN DXAS; including UL 514B.

2.14 JOINT COMPOUNDS

A. UL FOIZ - Electrically Conductive Corrosion-Resistant Compound for Threaded Conduit:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABB
   b. Plasti-Bond
   c. Kopr-Shield

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN FOIZ; including UL Subject 2419.

2.15 SOLVENT CEMENTS

A. UL VBEW - Solvent Cements for Nonmetallic Duct Raceways and Fittings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ALVA Manufacturing.
      b. Kraloy.
      c. IPEX Inc.
   2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. Solvent Cements: UL CCN VBEW; including UL 340.
      b. Solvent Cement Compatibility with PVC Conduit Fittings: UL CCN DWTT; including UL 514B. Follow solvent manufacturer's published instructions.
      c. Solvent Cement Compatibility with Rigid PVC Conduit: UL CCN DZYR; including UL 651. Follow solvent manufacturer's published instructions.
      d. Solvent Cement Compatibility with Rigid EPEC and HDPE Underground Conduit: UL CCN EAZX; including UL 651A. Follow solvent manufacturer's published instructions.

PART 3 - EXECUTION

3.1 SELECTION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in the Contract Documents or manufacturer's published instructions, comply with NFPA 70 for selection of duct raceways. Consult Architect for resolution of conflicting requirements.

B. Special Instructions Regarding HDPE Conduits: Although Article 353 of NFPA 70 permits use of HDPE conduits where encased in concrete aboveground, UL CCN EAZX listing requirements state that HDPE underground conduits are intended only for use where direct buried with or without being encased in concrete. Specified Type HDPE underground conduits are not permitted to be used aboveground on the Project.

C. Outdoors:
   1. Exposed and Subject to Severe Physical Damage: **ERMC**, **IMC**.
   2. Exposed and Subject to Physical Damage: **ERMC**, **IMC, Corrosion-resistant EMT**.
   3. Exposed and Not Subject to Physical Damage: **ERMC**, **IMC**, **Corrosion-resistant EMT**.

4. Concealed Aboveground: **ERMC, IMC**, **EMT**.
5. Direct Buried: **PVC-40**.
6. Concrete Encased Not in Trench: **PVC-40**, **PVC-A**.
7. Concrete Encased in Trench: **PVC-40**, **PVC-A**.
8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): **LFMC**.

D. Indoors:

1. Hazardous Classified Locations: **ERMC**, **IMC**.
2. Exposed and Subject to Severe Physical Damage: **ERMC**, **IMC**.
3. Exposed and Subject to Physical Damage: **ERMC**, **IMC**.
4. Exposed and Not Subject to Physical Damage: **EMT**.
5. Concealed in Ceilings and Interior Walls and Partitions: **EMT**.
6. Damp or Wet Locations: **ERMC**.
7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): **LFMC**.
8. Circuits Operating Above 60 Hz: **EMT-A**. Provide nonmetallic sleeve where aluminum duct raceways pass through concrete.

E. Duct Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.

1. ERMC and IMC: Provide threaded-type fittings unless otherwise indicated.

3.2 INSTALLATION OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Communications Work: BICSI N1.
6. Life Safety and Means of Egress Work: NFPA 101.
7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
8. Work in Confined Spaces: NFPA 350.
9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
10. Type EMT-A: Article 358 of NFPA 70 and NECA NEIS 102.
11. Type EMT-SS: Article 358 of NFPA 70 and NECA NEIS 101.

12. Type EMT-S: Article 358 of NFPA 70 and NECA NEIS 101.
13. Type ENT: Article 362 of NFPA 70 and NECA NEIS 102.
14. Type HDPE and Type EPEC: Article 353 of NFPA 70 and NECA NEIS 111.
15. Type ERMC-A: Article 344 of NFPA 70 and NECA NEIS 102.
16. Type ERMC-SS: Article 344 of NFPA 70 and NECA NEIS 101.
17. Type ERMC-S: Article 344 of NFPA 70 and NECA NEIS 101.
18. Type FMC-S: Article 348 of NFPA 70 and NECA NEIS 101.
19. Type FMC-A: Article 348 of NFPA 70 and NECA NEIS 102.
20. Type FMT: Article 360 of NFPA 70 and NECA NEIS 101.
21. Type IMC: Article 342 of NFPA 70 and NECA NEIS 101.
22. Type LFMC: Article 350 of NFPA 70 and NECA NEIS 101.
23. Type LFNC: Article 342 of NFPA 70 and NECA NEIS 111.
24. Type PVC: Article 356 of NFPA 70 and NECA NEIS 111.
25. Type RTRC: Article 355 of NFPA 70 and NECA NEIS 111.
26. Expansion Fittings: NEMA FB 2.40.
27. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. General Requirements for Installation of Duct Raceways:
   a. Complete duct raceway installation before starting conductor installation.
   b. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft (0.6 m) above finished floor.
   c. Install no more than equivalent of three 90-degree bends in conduit run except for control wiring conduits, for which no more than equivalent of two 90-degree fewer bends are permitted. Support within 12 inch (300 mm) of changes in direction.
   d. Make bends in duct raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
   e. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
   f. Support conduit within 12 inch (300 mm) of enclosures to which attached.
   g. Install duct sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed duct raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install duct sealing fittings in accordance with NFPA 70.

h. Install devices to seal duct raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of duct raceways at the following points:

1) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.

2) Where an underground service duct raceway enters a building or structure.

3) Conduit extending from interior to exterior of building.

4) Conduit extending into pressurized duct raceway and equipment.

5) Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

6) Where otherwise required by NFPA 70.

i. Do not install duct raceways or electrical items on "explosion-relief" walls or rotating equipment.

j. Do not install conduits within 2 inch (50 mm) of the bottom side of a metal deck roof.

k. Keep duct raceways at least 6 inch (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal duct raceway runs above water and steam piping.

l. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.

m. Install pull wires in empty duct raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb (90 kg) tensile strength. Leave at least 12 inch (300 mm) of slack at both ends of pull wire. Cap underground duct raceways designated as spare above grade alongside duct raceways in use.

n. Install duct raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.

1) Termination fittings with shoulders do not require two locknuts.

o. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

2. Types ERMC and IMC:

a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to threads of duct raceway and fittings before making up joints. Follow compound manufacturer's published instructions.

3. Type ERMC-S-PVC:
   a. Follow manufacturer's installation instructions for clamping, cutting, threading, bending, and assembly.
   b. Provide PVC-coated sealing locknut for exposed male threads transitioning into female NPT threads that do not have sealing sleeves, including transitions from PVC couplings/female adapters to Type ERMC-S-PVC elbows in direct-burial applications. PVC-coated sealing locknuts must not be used in place of conduit hub. PVC-coated sealing locknut must cover exposed threads on Type ERMC-S-PVC duct raceway.
   c. Coat field-cut threads on PVC-coated duct raceway with manufacturer-approved corrosion-preventing conductive compound prior to assembly.
4. Types FMC, LFMC, and LFNC:
   a. Provide a maximum of 36 inch (915 mm) of flexible conduit for recessed and semi-recessed luminaires**,** equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
5. Types PVC:
   a. Do not install Type PVC conduit where ambient temperature exceeds 122 deg F (50 deg C). Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
   b. Comply with manufacturer's published instructions for solvent welding and fittings.
   c. Join joints with solvent cement in accordance with manufacturer's published instructions and allowed to cure before handling. Joints to be bent, pushed, or pulled must set for minimum 24 h after joining.
6. Duct Raceways Embedded in Slabs:
   a. Run duct raceways larger than metric designator 27 (trade size 1) parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place duct raceway close to slab support. Secure duct raceways to reinforcement at maximum 10 ft (3 m) intervals.
   b. Arrange duct raceways to cross building expansion joints with expansion fittings at right angles to the joint.

c. Arrange duct raceways to ensure that each is surrounded by minimum of 2 inch (50 mm) of concrete without voids.

d. Do not embed threadless fittings in concrete unless locations have been specifically approved by Architect.

e. Change from ENT to PVC-40, ERMC or IMC before rising above floor.

7. Stub-ups to Above Recessed Ceilings:

a. Provide EMT, IMC, or ERMC for duct raceways.

b. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

8. Duct Raceway Terminations at Locations Subject to Moisture or Vibration:

a. Provide insulating bushings to protect conductors, including conductors smaller than 4 AWG. Install insulated throat metal grounding bushings on service conduits.

9. Duct Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.

a. EMT: Provide compression, steel fittings. Comply with NEMA FB 2.10.

b. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

10. Expansion-Joint Fittings:

a. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F (17 deg C) and that have straight-run length that exceeds 25 ft (7.6 m). Install in runs of aboveground ERMC and EMT conduit that are located where environmental temperature change may exceed 100 deg F (55 deg C) and that have straight-run length that exceeds 100 ft (30 m).

b. Install type and quantity of fittings that accommodate temperature change listed for the following locations:

1) Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.

2) Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.

3) Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.

4) Attics: 135 deg F (75 deg C) temperature change.

c. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F

(0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.

d. Install expansion fittings at locations where conduits cross building or structure expansion joints.

e. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's published instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

11. Duct Raceways Penetrating Rooms or Walls with Acoustical Requirements: Seal duct raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

12. Identification: Provide labels for conduit assemblies, duct raceways, and associated electrical equipment.

a. Provide warning signs.

D. Interfaces with Other Work:

1. Firestop penetrations of fire-rated floor and wall assemblies.

2. Provide conduit hangers and supports.

3.3 FIELD QUALITY CONTROL OF CONDUITS FOR ELECTRICAL SYSTEMS

A. Administrant for Electrical Power Tests and Inspections:

1. Owner will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.

2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.

3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Administrant for Communications Tests and Inspections:

1. Owner will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.

2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.

3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.

4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Acceptance Testing Preparation:
   1. Prepare testing and inspectin reports.
D. Field tests and inspections must be witnessed by authorities having jurisdiction.
E. Tests and Inspections:
   1. Perform manufacturer's recommended tests and inspections.
   2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 12 inch (300 mm) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
   3. Conduit Placement:
      a. Verify that center-line location and offsets are in accordance with the Drawings.
      b. Verify that hangers and supports for conduits are attached to structure as directed by qualified structural engineer.
      c. Verify that nuts on bolts or hanger rods are secure.
      d. Verify that space between raceways and cored holes are filled with non-shrinking grout or other approved material indicated on the Drawings and the Specifications.
      e. Verify that expansion devices are installed at locations indicated on the Drawings and the Specifications.
      f. Verify that ends are cut square to provide flush-butting surfaces when spliced and inside edges are free of burrs that could impede installation of cables.
      g. Verify minimum separation of utilities, or that approved mechanical protection has been provided to surrounding conduit(s) where minimum separation cannot be achieved.
   4. Document all changes on Record Drawings.
F. Nonconforming Work:
   1. Conduit will be considered defective if it does not pass tests and inspections.
   2. Remove and replace defective units and retest.
G. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.4 CLEANING

A. Verify that bentonite or other drilling fluids are contained and removed, and site is restored to its original or improved condition.

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.
   1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533.13

SECTION 260533.16

BOXES AND COVERS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metallic outlet boxes, device boxes, rings, and covers.
2. Nonmetallic outlet boxes, device boxes, rings, and covers.
3. Junction boxes and pull boxes.
4. Cover plates for device boxes.
5. Hoods for outlet boxes.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 078413 "Penetration Firestopping" specifies materials and methods for sealing penetrations of rated walls and partitions referenced by this Section.
5. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
7. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.

1.2 DEFINITIONS

A. Communications Outlet: One or more communications jacks, or cables and plugs, mounted in a box or ring, with a suitable protective cover.

B. Enclosure: The case or housing of an apparatus, or the fence or wall(s) surrounding an installation, to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. Types of enclosures and enclosure covers include the following:

1. Cabinet: An enclosure that is designed for either surface mounting or flush mounting and is provided with a frame, mat, or trim in which a swinging door or doors are or can be hung.
2. Concrete Box: A box intended for use in poured concrete.
3. Conduit Body: A means for providing access to the interior of a conduit or tubing system through one or more removable covers at a junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.
4. Conduit Box: A box having threaded openings or knockouts for conduit, EMT, or fittings.
5. Cover Plate: A cover designed for protecting wiring devices installed in flush-mounted device boxes while permitting their safe operation; also called a faceplate or wallplate.
6. Cutout Box: An enclosure designed for surface mounting that has swinging doors or covers secured directly to and telescoping with the walls of the enclosure.
7. Device Box: A box with provisions for mounting a wiring device directly to the box.
8. Extension Ring: A ring intended to extend the sides of an outlet box or device box to increase the box depth, volume, or both.
9. Floor Box: A box mounted in the floor intended for use with a floor box cover and other components to complete the floor box enclosure.
10. Floor-Mounted Enclosure: A floor box and floor box cover assembly with means to mount in the floor that is sealed against the entrance of scrub water at the floor level.
11. Floor Nozzle: An enclosure used on a wiring system, intended primarily as a housing for a receptacle, provided with a means, such as a collar, for surface-mounting on a floor, which may or may not include a stem to support it above the floor level, and is sealed against the entrance of scrub water at the floor level.
12. Junction Box: A box with a blank cover that joins different runs of raceway or cable and provides space for connection and branching of the enclosed conductors.
13. Outlet Box: A box that provides access to a wiring system having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for the entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting an outlet box cover, but without provisions for mounting a wiring device directly to the box.
14. Pedestal Floor Box Cover: A floor box cover that, when installed as intended, provides a means for typically vertical or near-vertical mounting of receptacle outlets above the floor's finished surface.
15. Pull Box: A box with a blank cover that joins different runs of raceway and provides access for pulling or replacing the enclosed cables or conductors.
16. Raised-Floor Box: A floor box intended for use in raised floors.

17. Recessed Access Floor Box: A floor box with provisions for mounting wiring devices below the floor surface.
18. Recessed Access Floor Box Cover: A floor box cover with provisions for passage of cords to recessed wiring devices mounted within a recessed floor box.
19. Ring: A sleeve, which is not necessarily round, used for positioning a recessed wiring device flush with the plaster, concrete, drywall, or other wall surface.
20. Ring Cover: A box cover, with raised center portion to accommodate a specific wall or ceiling thickness, for mounting wiring devices or luminaires flush with the surface.
21. Termination Box: An enclosure designed for installation of termination base assemblies consisting of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors, or both.

C. Receptacle: A fixed connecting device arranged for insertion of a power cord plug. Also called a power jack.

D. Receptacle Outlet: One or more receptacles mounted in a box with a suitable protective cover.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of product requiring samples for source quality control.

C. Shop Drawings: Prepare and submit the following:

1. Shop Drawings for Floor Boxes: Show that floor boxes are located to avoid interferences and are structurally allowable. Indicate floor thickness at location where boxes are embedded in concrete floors and underfloor clearances where boxes are installed in raised floors.
2. For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

C. Source quality-control reports.

1.5 QUALIFICATIONS – NOT USED

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Source Quality Control:

1. Samples:

a. Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

b. Raised Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

c. Recessed Access-Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

d. Concrete Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

B. UL QCIT - Metallic Outlet Boxes and Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN QCIT; including UL 514A.

2. Standard Features:

a. Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.

b. Material: Sheet steel.

c. Sheet Metal Depth: Minimum 1.5 inch (38 mm).

3. Other Available Features Required by the Project:

a. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing up to 50 lb (23 kg). Outlet boxes designed for

attachment of luminaires more than 50 lb (23 kg) and marked with maximum allowable weight.

C. UL QCIT - Metallic Conduit Bodies:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCIT; including UL 514A.
   2. Standard Features: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.

D. UL QCIT - Metallic Device Boxes:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCIT; including UL 514A.
   2. Standard Features:
      a. Box with provisions for mounting wiring device directly to box.
      b. Material: Sheet steel.
      c. Sheet Metal Depth: minimum 1.5 inch (38 mm).

E. UL QCIT - Metallic Extension Rings:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCIT; including UL 514A.
   2. Standard Features: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

F. UL QCIT - Metallic Floor Boxes and Floor Box Covers:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCIT; including UL 514A.
   2. Standard Features: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

G. UL QCIT - Metallic Raised-Floor Boxes and Floor Box Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN QCIT; including UL 514A.
2. Standard Features: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.

H. UL QCIT - Metallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN QCIT; including UL 514A.
2. Standard Features: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

2.3 NONMETALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Source Quality Control:

1. Samples:
   a. Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
   b. Raised Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
   c. Recessed Access-Floor Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.
   d. Concrete Box Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and flooring inserts for each type of floor box.

B. UL QCMZ - Nonmetallic Outlet Boxes and Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN QCMZ; including UL 514C.
2. Standard Features: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides or the back, or both, for entrance of conduit, conduit or cable fittings, or

cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.

C. UL QCMZ - Nonmetallic Conduit Bodies:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCMZ; including UL 514C.
   2. Standard Features: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.

D. UL QCMZ - Nonmetallic Device Boxes:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCMZ; including UL 514C.
   2. Standard Features: Box with provisions for mounting wiring device directly to box.

E. UL QCMZ - Nonmetallic Extension Rings:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCMZ; including UL 514C.
   2. Standard Features: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

F. UL QCMZ - Nonmetallic Floor Boxes and Floor Box Covers:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCMZ; including UL 514C.
   2. Standard Features: Box mounted in floor with floor box cover and other components to complete floor box enclosure.

G. UL QCMZ - Nonmetallic Raised-Floor Boxes and Floor Box Covers:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCMZ; including UL 514C.

2. Standard Features: Box mounted in raised-floor with floor box cover and other components to complete floor box enclosure.

H. UL QCMZ - Nonmetallic Recessed Access-Floor Boxes and Recessed Floor Box Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN QCMZ; including UL 514C.
2. Standard Features: Floor box with provisions for mounting wiring devices below floor surface and floor box cover with provisions for passage of cords to recessed wiring devices mounted within floor box.

I. UL QCMZ - Nonmetallic Floor Nozzles:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN QCMZ; including UL 514C.
2. Standard Features: Enclosure intended primarily as housing for receptacle, provided with means, such as collar, for surface-mounting on floor, which may or may not include stem to support it above floor level, and is sealed against the entrance of scrub water at floor level.

J. UL QCMZ - Nonmetallic Concrete Boxes and Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN QCMZ; including UL 514C.
2. Standard Features: Box intended for use in poured concrete.

2.4 JUNCTION BOXES AND PULL BOXES

A. UL BGUZ - Indoor Sheet Metal Junction and Pull Boxes:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:
   a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   b. Degree of Protection: Type 1.

B. UL BGUZ - Indoor Cast-Metal Junction and Pull Boxes:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:
   a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   b. Degree of Protection: Type 1.

C. UL BGUZ - Indoor Polymeric Junction and Pull Boxes:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:
   a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   b. Degree of Protection: Type 1.

D. UL BGUZ - Outdoor Sheet Metal Junction and Pull Boxes:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:
   a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   b. Degree of Protection: Type 3R.

E. UL BGUZ - Outdoor Cast-Metal Junction and Pull Boxes:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:
   a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
   b. Degree of Protection: Type 3R.

F. UL BGUZ - Outdoor Polymeric Junction and Pull Boxes:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
a. UL CCN BGUZ; including UL 50 and UL 50E.
2. Standard Features:
a. Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
b. Degree of Protection: Type 3R.

2.5 COVER PLATES FOR DEVICE BOXES

A. UL QCIT or QCMZ - Metallic Cover Plates for Device Boxes:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
2. Standard Features:
a. Cover plate-Securing Screws: Metal with head color to match cover plate finish.
b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
c. Cover Plate Material: 0.032 inch (0.8 mm) thick, Type 302/304 non-magnetic stainless steel with brushed finish.

B. UL QCIT or QCMZ - Nonmetallic Cover Plates for Device Boxes:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
2. Standard Features:
a. Cover Plate-Securing Screws: Metal with head color to match cover plate finish.
b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
c. Cover Plate Material: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device.
d. Color: in accordance with NEMA WD 1.

C. UL QCIT or QCMZ - Illuminating Cover Plates for Device Boxes:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
2. Standard Features:
   a. Cover Plate-Securing Screws: Metal with head color to match cover plate finish.
   b. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
   c. Cover Plate Material: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device.
   d. Color: in accordance with NEMA WD 1.

2.6 HOODS FOR OUTLET BOXES

A. UL QCIT or QCMZ - Retractable or Reattachable Hoods for Outlet Boxes:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
      b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
   2. Standard Features:
      a. Mounts to box using fasteners different from wiring device.
      b. Provides gray, weatherproof, "while-in-use" cover.

B. UL QCIT or QCMZ - Extra-Duty, While-in-Use Hoods for Outlet Boxes:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN QCIT or UL CCN QCMZ; including UL 514D.
      b. Receptacle, Hood, Cover Plate, Gaskets, and Seals: UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
   2. Standard Features:
      a. Mounts to box using fasteners different from wiring device.
      b. Marked "Extra-Duty" in accordance with UL 514D.
      c. Provides gray, weatherproof, "while-in-use" cover.
      d. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 - EXECUTION

3.1 SELECTION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:
   a. Type 3R unless otherwise indicated.
   b. Locations Exposed to Hosedown: Type 4X.
   c. Locations Subject to Potential Flooding: Type 6P.
   d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.
2. Indoors:
   a. Type 1 unless otherwise indicated.
   b. Damp or Dusty Locations: Type 4.
   c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
   d. Flush Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
   e. Locations Exposed to Airborne Dust, Lint, Fibers, or Flyings: Type 4

C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:

1. Provide cast-metal boxes, Boxes with knockouts or unprotected openings are prohibited.
2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.2 INSTALLATION OF BOXES AND COVERS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Commissioning of Active and Passive Fire Protection Features: NFPA 3 and NFPA 4.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Communications Work: BICSI N1.
6. Life Safety and Means of Egress Work: NFPA 101.

7. Emergency and Standby Power Work: NFPA 110, NFPA 111, and NECA NEIS 416.
8. Work in Confined Spaces: NFPA 350.
9. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
10. Outlet, Device, Pull, and Junction Boxes: Article 314 of NFPA 70.
11. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
2. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
3. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box, whether installed indoors or outdoors.
4. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
5. Locate boxes so that cover or plate will not span different building finishes.
6. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
7. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
8. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
9. Set metal floor boxes level and flush with finished floor surface.
10. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
11. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
12. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
13. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
    a. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
    b. Provide gaskets for cover plates and covers.

D. Interfaces with Other Work:

1. Identification: Provide labels for boxes and associated electrical equipment.
   a. Identify field-installed conductors, interconnecting wiring, and components.
   b. Label each enclosure with engraved metal or laminated-plastic nameplate.
   c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3.3 FIELD QUALITY CONTROL OF BOXES AND COVERS

A. Administrant for Electrical Power Tests and Inspections:
   1. Owner will engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
   2. Engage qualified medium-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
   3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
   4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Administrant for Communications Tests and Inspections:
   1. Owner will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
   2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
   3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
   4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Administrant for Security Tests and Inspections:
   1. Owner will engage qualified security testing and inspecting agency to administer and perform tests and inspections.
   2. Engage qualified security testing and inspecting agency to administer and perform tests and inspections.
   3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
   4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

D. Administrant for Fire-Alarm Tests and Inspections:

1. Owner will engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified fire-alarm testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

E. Acceptance Testing Preparation:
1. Prepare testing and inspection reporting.

F. Field tests and inspections must be witnessed by authorities having jurisdiction.

G. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
2. Perform tests and inspections recommended by standards listed in "Reference Standards for Installation" Paragraph.

H. Nonconforming Work:
1. Boxes and covers will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

I. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.4 CLEANING

A. Remove construction dust and debris from boxes before installing cover plates, covers, and hoods.

3.5 PROTECTION

A. After installation, protect boxes from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260533.16

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SECTION 260533.23

SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Surface metal raceways and fittings.
2. Surface nonmetallic raceways.
3. Strut-type channel raceways and fittings.
4. Wireways and auxiliary gutters.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, and other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260553 "Identification for Electrical Systems" specifies warning signs referenced by this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of product requiring samples for source quality control.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

1.4 QUALIFICATIONS – NOT USED

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 SURFACE METAL RACEWAYS AND FITTINGS

A. Source Quality Control:

1. Samples:

a. Surface Metallic Raceway Nonmetallic Cover Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch (300 mm) long.

B. UL RJBT - Surface Metal Raceways and Fittings with Metal Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN RJBT; including UL 5.

2. Standard Features:

a. Galvanized steel base with snap-on covers.

b. Manufacturer's standard enamel finish in color selected by Architect.

c. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.

C. UL RJBT - Surface Metal Raceways and Fittings with Nonmetallic Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. UL CCN RJBT; including UL 5.

2. Standard Features:

a. UL 94, V-0 requirements for self-extinguishing characteristics.

b. Galvanized steel base with snap-on covers.

c. Provide texture and color selected by Architect from manufacturer's standard colors.

d. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.

2.3 SURFACE NONMETALLIC RACEWAYS

A. Source Quality Control:

1. Samples:

a. Surface Nonmetallic Raceway Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch (300 mm) long.

B. UL RJTX - Surface Nonmetallic Raceways and Fittings with Nonmetallic Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN RJTX; including UL 5A.
   b. UL 94, V-0 requirements for self-extinguishing characteristics.
2. Standard Features:
   a. Provide texture and color selected by Architect from manufacturer's standard colors.
   b. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.

C. UL RJTX - Surface Nonmetallic Raceways and Fittings with Metallic Covers:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN RJTX; including UL 5A.
   b. UL 94, V-0 requirements for self-extinguishing characteristics.
2. Standard Features:
   a. Manufacturer's standard enamel finish in color selected by Architect.
   b. Wiring Channels: Single. Multiple channels must be capable of housing a standard 20 to 30 A device flush within the raceway.

2.4 STRUT-TYPE CHANNEL RACEWAYS AND FITTINGS

A. Source Quality Control:
1. Samples:
   a. Strut-Type Channel Raceway Nonmetallic Covers for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch (300 mm) long.

B. UL RIUU - Strut-Type Channel Raceways and Fittings with Metallic Covers:
1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN RIUU; including UL 5B.
2. Standard Features:
   a. Manufacturer's standard enamel finish in color selected by Architect.

C. UL RIUU - Strut-Type Channel Raceways and Fittings with Nonmetallic Covers:

1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. UL CCN RIUU; including UL 5B.
   b. UL 94, V-0 requirements for self-extinguishing characteristics.
2. Standard Features:
   a. UL 94, V-0 requirements for self-extinguishing characteristics.
   b. Provide texture and color selected by Architect from manufacturer's standard colors.

2.5 WIREWAYS AND AUXILIARY GUTTERS

A. Source Quality Control:
   1. Samples:
      a. Nonmetallic Wireway and Auxiliary Gutter Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type, 12 inch (300 mm) long.

B. UL ZOYX - Metal Wireways and Auxiliary Gutters:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN ZOYX; including UL 870.
   2. Standard Features:
      a. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
      b. Finish: Manufacturer's standard enamel finish.
      c. Wireway Covers: Hinged type unless otherwise indicated.
   3. Other Available Features Required by the Project:
      a. Degree of Protection: Type 1 unless otherwise indicated.

C. UL ZOYX - Nonmetallic Wireways and Auxiliary Gutters:
   1. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
      a. UL CCN ZOYX; including UL 870.
      b. UL 94, V-0 requirements for self-extinguishing characteristics.
   2. Standard Features:

a. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings must match and mate with wireways as required for complete system.

b. PVC Solvents and Adhesives: As recommended by wireway manufacturer.

c. Material:

1) Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover must be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections must be flanged and have stainless steel screws and oil-resistant gaskets.

2) PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
4. Communications Work: BICSI N1.
5. Work in Confined Spaces: NFPA 350.
6. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
7. Auxiliary Gutters: Article 366 of NFPA 70.
8. Surface Metal Raceway: Article 386 of NFPA 70.
9. Surface Nonmetallic Raceway: Article 388 of NFPA 70.
10. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Install surface raceways only where indicated on Drawings.
2. Install surface raceway with a minimum 2 inch (50 mm) radius control at bend points.
3. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's published instructions. Tape and glue are unacceptable support methods.

D. Interfaces with Other Work:

1. Identification: Provide labels for surface raceways and associated electrical equipment.
   a. Identify field-installed conductors, interconnecting wiring, and components.
   b. Provide warning signs.

3.2 FIELD QUALITY CONTROL OF SURFACE RACEWAYS – NOT USED

3.3 CLEANING

A. Remove construction dust and debris from surface raceways before installing covers.

3.4 PROTECTION

A. After installation, protect surface raceways from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 260533.23

SECTION 260546

POLES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lighting standards.
2. Lighting standard accessories.
3. Utility poles.
4. Utility pole accessories.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding components referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 260573 "Power System Studies" specifies arc-flash hazard analysis and warning labels referenced by this Section.
8. Section 262726 "Wiring Devices", Section 262726.31 "General-Grade Single Straight-Blade Receptacles", and [Section 262726.33 "General-Grade Duplex Straight-Blade Receptacles" specify receptacles referenced by this Section.

1.2 DEFINITIONS

A. Bonding: The electrical interconnecting of conductive parts, designed to maintain a common electrical potential.

B. EPA: Equivalent projected area.

C. Grounding (Earthing): Electrically connecting, whether intentional or accidental, an electrical circuit or equipment to the earth, or to some conducting body that serves in place of the earth.

D. Guy: A tension member having one end securely anchored and the other end attached to a pole or other structure that it supports against overturning.

E. Lighting Standard: An upright pole or beam used to support luminaires and used as a raceway to enclose supply conductors. Lighting standards frequently include provisions for supporting and supplying decorative items such as holiday decorations, flags, or banners.

F. Pole: A column of wood or steel, or some other material, supporting overhead conductors, usually by means of arms or brackets.

1.3 DELEGATED DESIGN SERVICES – NOT USED

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.
2. Include finishes for lighting poles and luminaire-supporting devices.
3. Anchor bolts.
4. Manufactured pole foundations.
5. Product Certificates: Include product certificate, signed by manufacturers of poles, certifying that products are designed for indicated load requirements in accordance with AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification must be based on design calculations signed and sealed by a professional engineer.
6. Include manufacturer's sample extended warranty language.

B. Samples: Submit finish samples for each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

C. Shop Drawings: Prepare and submit the following:

1. Plans, elevations, sections, and mounting and attachment] details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Details of fabrication and assembly of poles and pole accessories.
4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
6. Method and procedure of pole installation. Include manufacturer's published installations.

D. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Material Test Reports:

1. For each foundation component, by qualified testing laboratory.
2. For each pole, by qualified testing laboratory.

B. Soil test reports.

C. Manufacturer's published instructions.

D. Field Reports:

1. Manufacturer's field reports for field quality-control support.

1.6 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Spare parts.

B. Special tools.

1.8 REGULATORY AGENCY APPROVALS

A. Submittals for poles requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.

1.9 QUALIFICATIONS – NOT USED

1.10 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping in accordance with ASTM B660.

B. Store poles on decay-resistant skids at least 12 inch (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole installed below finished grade.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until immediately before pole installation. Handle poles with web fabric straps.

1.11 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed pole(s) and luminaire-lowering device(s) perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Extended-Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that pole(s) and luminaire-lowering device(s) perform in accordance with specified requirements and agrees to provide repair or replacement of products that fail to perform as specified within extended-warranty period, including materials that corrode, fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Extended-Warranty Period: Five years from date of Substantial Completion; full coverage for labor, materials, and equipment.
2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion; full coverage for labor, materials, and equipment.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Performance Criteria:

1. Regulatory Requirements:
   a. Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Utility Approval: Comply with utility requirements.
3. General Characteristics:
   a. Structural Characteristics: Comply with AASHTO LTS-6-M.
   b. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied in accordance with AASHTO LTS-6-M.
   c. Live Load: Single load of 500 lb (2200 N) distributed in accordance with AASHTO LTS-6-M.
   d. Ice Load: Load of 3 lb/ft^2 (145 Pa), applied in accordance with AASHTO LTS-6-M for applicable areas on the Ice Load Map.
   e. Wind Load for Poles Exceeding 50 ft (15 m) Height:
      1) Basic Wind Speed: 130 mile/h (58 m/s).
      2) Wind Importance Factor: 1.0
      3) Minimum Design Life: 50 years.
      4) Velocity Conversion Factor: 1.0.
   f. Wind Load for Poles Not Exceeding 50 ft (15 m) Height:

1) Basic Wind Speed: 100 mile/h (45 m/s).
2) Wind Importance Factor: 1.0
3) Minimum Design Life: 25 years
4) Velocity Conversion Factor: 1.0.

g. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA used in pole selection strength analysis.

h. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.

i. General Finish Requirements:

1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
2) Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.2 LIGHTING STANDARDS

A. Steel Lighting Standard:

1. Source Limitations: For lighting standards, obtain each color, grade, finish, type, and variety of lighting standard from single source with resources to provide products of consistent quality in appearance and physical properties.
2. Standard Features:

a. Comply with requirements in Article 410 of NFPA 70 for luminaire supports.

b. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless steel fasteners and mounting bolts unless otherwise indicated.

c. General Finish Requirements:

1) Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
2) Appearance of the Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

d. Carbon Steel Poles: Comply with ASTM A500/A500M, Grade B carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 ft (12 m) in height with access handhole in lighting standard wall.
   1) Shape: Square, straight.
   2) Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

e. Steel Mast Arms: Single-arm type, continuously welded to lighting standard attachment plate. Material and finish same as plate.

f. Brackets for Luminaires: Detachable, cantilever, without underbrace.
   1) Adaptor fitting welded to lighting standard, allowing the bracket to be bolted to the lighting standard-mounted adapter, then bolted together with **galvanized-steel** bolts.
   2) Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match lighting standard material and finish.

g. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to lighting standard top.

h. Grounding and Bonding Lugs: Welded 1/2 inch (13 mm) threaded lug, listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

i. Steps: Fixed steel, with nonslip treads.
   1) For climbing positions, install at 15 inch (381 mm) vertical spacing, alternating on opposite sides of lighting standard, oriented 180 degrees from each other; first step must be at an elevation 10 ft (3 m) above finished grade.
   2) For working positions, install steps on opposite side of lighting standard, oriented 180 degrees from each other at the same elevation.

j. Handhole: Oval shaped, with minimum clear opening of 2-1/2-by-5 inch (65-by-130 mm), with cover secured by stainless steel captive screws.

k. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5 inch (76-by-130 mm) handhole located at midpoint of lighting standard, with cover for access to internal welded attachment lug for electric cable support grip.

l. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

m. Platform for Lamp Ballast Servicing: Factory fabricated of steel, with finish matching that of lighting standard.

n. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

o. Galvanized Finish: After fabrication, hot-dip galvanize in accordance with ASTM A123/A123M.

p. Factory-Painted Finish: Comply with NAAMM/NOMMA AMP 500 recommendations for applying and designating finishes.

1) Surface Preparation: Clean surfaces in accordance with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, in accordance with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2) Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

3) Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a) Color: As selected by Architect from manufacturer's full range.

q. Powder-Coat Finish: Comply with NAAMM/NOMMA AMP 500 recommendations for applying and designating finishes.

1) Surface Preparation: Clean surfaces in accordance with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder-coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, in accordance with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2) Powder Coat: Comply with AAMA 2604.

a) Electrostatic-applied powder coating; single application and cured to a minimum 2.5 to 3.5 mil (64 to 89 µm) dry film thickness. Coat interior and exterior of lighting standard for equal corrosion protection.

b) Color: As selected by Architect from manufacturer's full range.

3. Other Available Features Required by the Project:

a. Fasteners: Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1) Materials: Compatible with lighting standards as well as the substrates to which lighting standards are fastened and may not cause galvanic action at contact points.

2) Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

2.3 LIGHTING STANDARD ACCESSORIES

A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V(ac), 20 A in a weatherproof assembly.

1. Surface mounted 12 inch (300 mm) above finished grade.

a. UL 50E, Type 3R, nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.

b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.

B. Minimum 1800 W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

D. Transformer-Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and to accept ballast(s). Include removable flanged access cover secured with bolts or screws.

E. Mounting Hardware:

1. Anchor Bolts: Manufactured to ASTM F1554, Grade 55, with a minimum yield strength of 55,000 psi (380 000 kPa).

a. Galvanizing: Hot-dip galvanized in accordance with ASTM A153/A153M, Class C.

b. Headed rods.

c. Threading: Uniform National Coarse, Class 2A.

2. Nuts: ASTM A563/A563M, Grade A, Heavy-Hex.

a. Galvanizing: Hot-dip galvanized in accordance with ASTM A153/A153M, Class C.

b. Two nuts provided per anchor bolt, shipped with nuts preassembled to the anchor bolts.

3. Washers: ASTM F436/F436M, Type 1.

a. Galvanizing: Hot-dip galvanized in accordance with ASTM A153/A153M, Class C.

b. One washer(s) provided per anchor bolt.

2.4 UTILITY POLES – NOT USED

2.5 UTILITY POLE ACCESSORIES – NOT USED

2.6 MAINTENANCE MATERIAL ITEMS

A. Spare Parts: Furnish to Owner spare parts, for repairing lighting standards and poles, that are packaged with protective covering for storage on-site and identified with labels describing contents.

B. Special Tools: Furnish to Owner proprietary equipment and keys required to operate, maintain, repair, adjust, or implement future changes to lighting standards and poles, that are packaged with protective covering for storage on-site and identified with labels describing contents.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

3.2 INSTALLATION OF FOUNDATIONS FOR POLES AND LIGHTING STANDARDS

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Precast Foundations: Factory fabricated, with structural steel complying with ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.

1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Direct-Buried Foundations: Install to depth indicated on the Drawings, but not less than **one-**sixth of pole height. Add backfill in 6 to 9 inch (150 to 230 mm) layers, tamping each layer before adding the next. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on the Drawings, but not less than one-sixth of pole height. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

1. Make holes 6 inch (150 mm) in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days and finish in a dome above finished grade.
3. Use a short piece of 1/2 inch (13 mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Anchor Bolts: Install plumb using manufacturer-supplied steel template, uniformly spaced.

3.3 INSTALLATION OF LIGHTING STANDARDS

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Hot Work: NFPA 51B.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Alignment: Align lighting standards as indicated.
2. Clearances: Maintain the following minimum horizontal distances of lighting standards from surface and underground features unless otherwise indicated on the Drawings:
   a. Fire Hydrants and Water Piping: 60 inch (1520 mm).
   b. Water, Gas, Electric, Communications, and Sewer Lines: 10 ft (3 m).
   c. Trees: 15 ft (5 m) from tree trunk.
3. Concrete Lighting Standard Foundations: Set anchor bolts in accordance with anchor-bolt templates furnished by manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."
4. Foundation-Mounted Lighting Standards: Mount lighting standards with leveling nuts and tighten top nuts to torque level in accordance with manufacturer's published instructions.
   a. Use anchor bolts and nuts selected to resist seismic forces specified for the application and approved by manufacturer.
   b. Grout void between lighting standard base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   c. Install base covers unless otherwise indicated.

d. Use a short piece of 1/2 inch (13 mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of lighting standard.

5. Lighting Standards and Foundations Set in Concrete-Paved Areas: Install lighting standards with a minimum 6 inch (150 mm) wide, unpaved gap between the lighting standard or foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch (25 mm) below top of concrete slab.

6. Raise and set lighting standard using web fabric slings (not chain or cable) at locations indicated by manufacturer.

7. Corrosion Prevention:

a. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

b. Steel Conduits: Comply with requirements in Section 260533.13 "Conduits for Electrical Systems." In concrete foundations, wrap conduit with 0.010 inch (0.254 mm) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

D. Interfaces with Other Work:

1. Grounding and Bonding: Bond metallic components of lighting standards and support structures as follows:

a. Provide insulated equipment grounding conductors with supply feeders for bonding luminaires and other pole-mounted electrical or electronic equipment to ground terminals of their supplying power sources in accordance with Article 250 of NFPA 70.

b. Bond metallic components of luminaires, pole accessories, and foundation to insulated equipment grounding conductor.

2. Identification: Provide labels for lighting standards, components, wiring, cabling, terminals, and associated electrical equipment.

a. Identify field-installed conductors, interconnecting wiring, and components.

b. Label each enclosure with engraved metal or laminated-plastic nameplate.

c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.

3.4 INSTALLATION OF UTILITY POLES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: NFPA 70 and NECA NEIS 1.

2. Electrical Safety: NFPA 70E.

3. Hot Work: NFPA 51B.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Communications Work: BICSI N1.
6. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Engage the services of a licensed surveyor to verify dimensions by field measurement, to identify locations of poles, anchors, and other features, and to verify all clearances. The survey document must also identify locations of connections to new and existing supply lines and to primary and secondary services. Notify Architect of discrepancies and field conditions that are not indicated and that will affect installation.
2. Pole Orientation: Align curve of curved wood poles with straight-line runs of three or more poles. Align gained surfaces perpendicular to runs.
3. Elevation of Line above Grade: Install poles with top at same elevation, unless grade changes dictate elevation change in poles, and in accordance with the following:
   a. On level ground, set poles so tops of consecutive poles vary not more than 60 inch (1500 mm) in elevation.
   b. Shorten wood poles by cutting off the top and make cuts to shed water. Apply preservative to cuts.
4. Set poles in accordance with the following:
   a. Make pole holes vertical, uniform in diameter, and large enough to permit effective use of tamping bars all around. Bore or excavate holes with an average diameter at grade less than twice the diameter of the pole at the same grade.
   b. Use minimum depths indicated, except at locations where hole is partly or entirely in rock and if hole is not vertical or has a diameter at grade more than two times the pole diameter at the same level; in these conditions, increase the depth of the hole by the following increments before setting the pole:
      1) Poles up to 35 ft (10.6 m) Long: 24 inch (600 mm).
      2) Poles 36 to 60 ft (11 to 18.3 m) Long: 30 inch (760 mm).
      3) Poles 61 to 75 ft (18.6 to 22.9 m) Long: 36 inch (900 mm).
   c. For poles on slopes, indicated hole depth is from finished grade at lowest side of hole.
   d. Set poles in alignment and plumb except at dead ends, angles, and points of extra strain; rake poles against conductor strain 1 inch (25 mm) minimum, 2 inch (51 mm) maximum, (after conductors are installed at required tension) for each 10 ft (3 m) of pole length. Rake poles so they will not lean or bend in direction of strain when loaded.

e. Backfill holes in 6 inch (150 mm) maximum lifts, and thoroughly tamp each layer before starting the next.

f. Place surplus earth around pole in a conical shape, and tamp thoroughly to provide drainage away from pole.

g. Set poles so alternate crossarm gains face in alternate directions, except at terminals and dead ends; place gains on last two poles on side facing terminal or dead end.

h. Poles Set in Concrete Paved Areas: Install poles with minimum of 6 inch (150 mm) wide, unpaved gap between the pole and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

5. Field treat factory-treated poles and crossarms as follows:

a. Poles Treated More Than One Year before Installation: Treat portion from 24 inch (600 mm) above ground line to butt.

b. Field-Bored Holes and Field-Cut Gains and Pole Tops: Treat cut portions.

c. Unused Holes: Treat and plug with treated-wood-dowel drive pins.

d. Engage the services of qualified wood pole and crossarm treatment technician to apply treatment. Comply with requirements in AWPA standards that govern original factory treatment for field-applied treatment and application of chemicals.

6. Installation of Crossarms: Set line crossarms at right angle to line for straight runs and for angles 45 degrees and more. Bisect angles less than 45 degrees.

a. Buck Arms: Install at corners and junction poles unless otherwise indicated.

b. Double Crossarms: Install at dead ends, corners, angles, and line crossings.

c. Equipment Arms: Locate below lines and set parallel or at right angles to them, whichever provides best climbing space.

d. Gains: Install factory-cut or metal-pole gains only. Do not cut gains in field without specific written approval.

7. Installation of Guys and Anchors:

a. Install guys to resist unbalanced loads, including those developed at angles, corners, and dead ends. Install two or more guys if a single guy will not provide adequate strength. Install separate guys if unbalanced loads are separated by 36 inch (900 mm) or more. Comply with IEEE C2.

1) Unless a thimble eye is used, at the pole end, install a minimum of two guy hooks and two guy strain plates.

2) At the anchor end, attach guy strand assembly with preformed grips.

b. Protect guy strands from damage. Replace damaged guy strands. Install guy insulators where required to comply with IEEE C2 clearance requirements.

c. Install guys with a lead-to-height ratio of 1 to 1 unless otherwise indicated. The minimum lead-to-height ratio must be 1/2 to 1. When less than 1 to 1, increase guy strength by the ratio of the sine of the lead angle indicated to the sine of the lead angle provided.

d. Install screw-type guy anchors aligned in soil with guy. Set with anchor rod pointing at guy attachment on pole and rod projecting 6 to 9 inch (150 to 230 mm) from ground.

e. Install strain insulators to provide a minimum of 12 inch (300 mm) of clearance between the nearest energized surface and the strain insulator fitting farthest from the pole. When loaded to the tension indicated, fiberglass strain insulators must be loaded to not more than two-thirds of manufacturer's published rating.

8. Guy Markers: Install at anchor end of guys to visually mark the guy wire at all accessible locations. Clamp to guy strand or anchor at top and bottom of marker.

D. Interfaces with Other Work:

1. Grounding and Bonding:

a. Comply with NFPA 70 grounding and bonding requirements.

b. Ground Rods: Copper-clad steel; 3/4 inch by 10 ft (19 mm by 3 m).

1) Install two parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 Ω.

2) Drive ground rods until tops are 12 inch (300 mm) below finished grade in undisturbed earth.

c. Grounding (Earthing) Conductors:

1) 4 AWG minimum, soft-drawn copper.

2) Conductor Protectors for Wood Poles: Half-round PVC or wood molding; if wood, use pressure-treated fir, cypress, or cedar. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communications service and transformer spaces.

3) Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.

4) Lightning Arrester Grounding Conductors: Separate from other grounding conductors.

d. Bonding Conductors: Provide equipment grounding conductors with supply feeders for bonding pole-mounted electrical and electronic equipment to ground terminals of their supplying power sources in accordance with Article 250 of NFPA 70.

2. Identification: Provide labels for poles, components, wiring, cabling, terminals, and associated electrical equipment.
   a. Identify field-installed conductors, interconnecting wiring, and components.
   b. Label each enclosure with engraved metal or laminated-plastic nameplate.
   c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
   d. Locate pole numbers to provide maximum visibility from the road or patrol route.

3.5 FIELD QUALITY CONTROL

A. Administrant for Electrical Power Tests and Inspections:
   1. Owner will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
   2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
   3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
   4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Acceptance Testing Preparation:
   1. Prepare testing and inspection reports.

C. Field tests and inspections must be witnessed by authorities having jurisdiction.

D. Tests and Inspections:
   1. Inspect poles for nicks, mars, dents, scratches, and other damage.
   2. System function tests.
   3. Guy Anchors: Test one of each type and capacity installed, plus additional units specifically indicated for testing. Apply rated pull-out force in the same pull direction applied by the guy at the test location.
      a. Acceptable Test Results: Denoted by movement of less than 3/8 inch (10 mm) by the holding component of the anchor in the earth or other medium in which it is installed.
      b. Replace or reinstall, at Architect's option, all anchors of same type and capacity as anchor type that fails this test.
   4. Pole Ground Resistance: Measure resistance of each separate grounding electrode, including pole grounds. Also measure resistance of separate grounding electrode systems before bonding together.
      a. Perform tests and obtain acceptable results before energizing any portion of overhead electrical distribution system.

b. Results and Follow-up: If ground resistance for a single ground electrode or pole ground, tested individually, exceeds 25 Ω, add a ground electrode not less than 10 ft (3 m) away and interconnect with 2 AWG, minimum, bare conductor buried at least 12 inch (300 mm) below furnished grade.

E. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

G. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

END OF SECTION 260546

SECTION 260548

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vibration controls.
2. Seismic and wind controls.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.

1.2 DEFINITIONS

A. Designated Seismic System: An architectural, electrical, or mechanical system and its components for which the component importance factor is greater than 1.0 when determined in accordance with Section 018123 "Facility Seismic and Wind Criteria."

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 DELEGATED DESIGN SERVICES

A. Delegated Design Professionals: Engage qualified structural professional engineer to design seismic and wind controls.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Prepare and submit catalog cuts, brochures, diagrams, schedules, and performance data illustrating size, physical appearance, and other characteristics of product.
    a. Include rated load capacity for each seismic- and wind-restraint device.
    b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic- and wind-restraint component used.

c. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by an agency acceptable to authorities having jurisdiction.

d. Annotate to indicate application of each product submitted and compliance with requirements.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.

2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

3. Show coordination of seismic and wind bracing for components with other systems and equipment in the vicinity, including other supports and seismic restraints.

C. Delegated Design Submittals:

1. For each seismic-restraint device that is required by this Section or is indicated on the Drawings, submit the following:

a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.

b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic criteria. Include certification that device is approved by qualified testing laboratory for seismic reinforcement use.

c. Seismic Design Calculations: Submit input data and loading calculations.

2. For each wind-restraint device that is required by this Section or is indicated on the Drawings, submit the following:

a. Wind Restraint: Select wind restraints complying with performance requirements, design criteria, and analysis data.

b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated wind criteria. Include certification that device is approved by qualified testing laboratory for reinforcement use.

c. Wind Design Calculations: Submit static and dynamic loading calculations.

3. Seismic- and Wind-Restraint Detail Drawings:

a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.

b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of

forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint details with wind details required for equipment mounted outdoors.

4. Product Listing, Preapproval, and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

D. Field quality-control reports.

1.5 REGULATORY AGENCY APPROVALS

A. Delegated design submittals and shop drawings requiring approval by authorities having jurisdiction must be signed by qualified structural professional engineer responsible for their preparation. Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.

1.6 QUALIFICATIONS

A. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including design of seismic and wind controls, equipment hangers and supports, and concrete foundations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Prepare design calculations in accordance with criteria specified in Section 260010 "Supplemental Requirements for Electrical" and Section 018123 "Facility Seismic and Wind Criteria."

B. Seismic and Wind Restraint Device Ratings: Devices must be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices must be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: an agency acceptable to authorities having jurisdiction.

C. Consequential Damage: Provide additional seismic and wind restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component will not cause failure of any other essential building component.

D. Fire/Smoke Resistance: Seismic- and wind-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by qualified testing laboratory in accordance with ASTM E84 or UL 723, and be so labeled.

E. Component Supports:

1. Load ratings, features, and applications of reinforcement components must be based on testing standards of qualified testing laboratory.

2.2 VIBRATION CONTROLS – NOT USED

2.3 SEISMIC AND WIND CONTROLS

A. Restraints - Rigid Type:

1. Standard Features: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

B. Restraints - Cable Type:

1. Standard Features:

a. Seismic- and Wind-Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.

b. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

C. Restraint Accessories:

1. Standard Features:

a. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.

b. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

c. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

d. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

e. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

D. Mechanical Anchor Bolts:
   1. Standard Features:
      a. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.
      b. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
      c. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

E. Adhesive Anchor Bolts:
   1. Standard Features
      a. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
      b. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
      c. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.

F. Concrete Inserts:
   1. Standard Features:
      a. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.
      b. Comply with MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive seismic and wind control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 SELECTION OF VIBRATION AND SEISMIC CONTROLS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install where indicated or scheduled on the Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry static, wind, and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC AND WIND CONTROLS

A. Provide seismic and wind control devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind Controls Schedule, where indicated on the Drawings, where the Specifications indicate they must be installed on specific equipment and systems, and where required by applicable codes.

1. Install equipment and devices to withstand the effects of earthquake motions and high wind events.

B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."

C. Installation of seismic and wind restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.

D. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint and wind-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint and wind-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
3. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
4. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Post-Installed Concrete Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor will be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

J. Accommodation of Differential Seismic Motion: Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Field tests must be witnessed by authorities having jurisdiction.

B. Special Structural Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.

4. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

C. Nonconforming Work:
1. Seismic controls will be considered defective if they do not pass tests and inspections.
2. Remove and replace malfunctioning units and retest as specified above.

D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

END OF SECTION 260548

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Extruded insulating tubing.
3. Bands.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Identification Schedule: For each piece of electrical equipment and electrical system components to be index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 LABELS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN PGDQ2 for components; including UL 969.

B. UL PGDQ2 - Vinyl Wraparound Labels: Preprinted, flexible labels laminated with clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

C. UL PGDQ2 - Self-Adhesive Wraparound Labels: Preprinted, 3 mil (0.08 mm) thick, polyester flexible label with acrylic pressure-sensitive adhesive.

1. Self-Lamination: Clear; UV-, weather-, and chemical-resistant; self-laminating, with protective shield over legend. Size labels such that clear shield overlaps entire printed legend.
2. Marker for Labels:
   a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
   b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. UL PGDQ2 - Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3 mil (0.08 mm) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.

1. Minimum Nominal Size:
   a. 1-1/2 by 6 inch (37 by 150 mm) for raceway and conductors.
   b. 3-1/2 by 5 inch (76 by 127 mm) for equipment.
   c. As required by authorities having jurisdiction.

2.2 EXTRUDED INSULATING TUBING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN YDPU2 for components; including UL 224.

B. UL YDPU2 - Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at maximum of 200 deg F (93 deg C).

2.3 BANDS

A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inch (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.

2.4 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil (0.08 mm) thick by 1 to 2 inch (25 to 50 mm) wide; compounded for outdoor use.

C. Tape and Stencil: 4 inch (100 mm) wide black stripes on 10 inch (250 mm) centers placed diagonally over orange background and are 12 inch (300 mm) wide. Stop stripes at legends.

D. Floor Marking Tape: 2 inch (50 mm) wide, 5 mil (0.125 mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

E. Underground-Line Warning Tape:

1. Tape:
   a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical [and communications] utility lines.
   b. Printing on tape must be permanent and may not be damaged by burial operations.
   c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
2. Color and Printing:
   a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.
   b. Inscriptions for Red Tapes: "CAUTION BURIED ELECTRIC LINE BELOW".
   c. Inscriptions for Orange Tapes: "CAUTION BURIED CATV LINE BELOW", "CAUTION BURIED TELEPHONE LINE BELOW", "CAUTION BURIED FIBER OPTIC LINE BELOW", "CAUTION BURIED COMMUNICATION LINE BELOW".
3. Nonconducting Line-Warning Tape:
   a. Pigmented polyolefin, bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
   b. Width: 3 inch (75 mm).
   c. Thickness: 4 mil (0.1 mm).
   d. Weight: 18.5 lb/1000 sq. ft (9.0 kg/100 sq. m).
   e. Tensile in accordance with ASTM D882: 30 lbf (133.4 N) and 2500 psi (17.2 MPa).
4. Reinforced Nonconducting Line-Warning Tape:
   a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
   b. Width: 3 inch (75 mm).
   c. Thickness: 12 mil (0.3 mm).
   d. Weight: 36.1 lb/1000 sq. ft (17.6 kg/100 sq. m).

e. Tensile in accordance with ASTM D882: 400 lbf (1780 N) and 11,500 psi (79.2 MPa).

5. Detectable Line-Warning Tape:
   a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
   b. Width: 3 inch (75 mm).
   c. Overall Thickness: 5 mil (0.125 mm).
   d. Foil Core Thickness: 0.35 mil (8.9 m).
   e. Weight: 28 lb/1000 sq. ft (13.7 kg/100 sq. m).
   f. Tensile in accordance with ASTM D882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).
6. Reinforced Detectable Line-Warning Tape:
   a. Reinforced, detectable three-layer laminate, consisting of printed pigmented woven scrim, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright-colored, continuous-printed on one side with inscription of utility, compounded for direct-burial service.
   b. Width: 3 inch (75 mm).
   c. Overall Thickness: 8 mil (0.2 mm).
   d. Foil Core Thickness: 0.35 mil (8.9 m).
   e. Weight: 34 lb/1000 sq. ft (16.6 kg/100 sq. m).
   f. Tensile in accordance with ASTM D882: 300 lbf (1334 N) and 12,500 psi (86.1 MPa).

F. Concrete Cable Route Markers:
1. Description: Concrete markers visually aid tracing the route of electrical cables. Monument markers are typically installed at grade. Protective cover markers are typically installed above the cables at grade or below grade.
2. Product Characteristics:
   a. Material: Precast reinforced concrete.
   b. Marker Type:
      1) Above-Ground Monument Post:
         a) Nominal Dimensions (Height, Width, Depth): 30 inch (760 mm), 6 inch (150 mm), 3 inch (75 mm).
      2) Above-Ground Monument Block:

a) Nominal Dimensions (Height, Width, Depth): 12 inch (300 mm), 12 inch (300 mm), 6 inch (150 mm).

3) In-Ground Protective Cover (Plank or Slab):

a) Nominal Dimensions (Length, Width, Depth): 36 inch (914 mm), 6 inch (150 mm), 2 inch (50 mm)

c. Legend: "DANGER - ELECTRICITY.

d. Lettering: Approximately 1/8 inch (3 mm) deep, not less than [1 inch (25 mm)] [1.5 inch (38 mm)] high, symmetrically spaced; marked on both sides to allow for reversal.

3. Required Product Options:

a. Color: Red dye added to concrete during batching.

b. Attach metal medallion or sign stamped with feeder number.

G. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height must be 1 inch (25 mm).

2.5 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023 inch (0.58 mm) thick, color-coded for phase and voltage level, with factory screened permanent designations; punched for use with self-locking cable tie fastener.

C. Write-on Tags:

1. Polyester Tags: 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment.

2. Marker for Tags:

a. Permanent, waterproof, black ink marker recommended by tag manufacturer.

b. Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.6 SIGNS

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.

2. 1/4 inch (6.4 mm) grommets in corners for mounting.

3. Nominal Size: 7 by 10 inch (180 by 250 mm).

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396 inch (1 mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
2. 1/4 inch (6.4 mm) grommets in corners for mounting.
3. Nominal Size: 10 by 14 inch (250 by 360 mm).

C. Laminated Acrylic or Melamine Plastic Signs:

1. Engraved legend.
2. Thickness:
   a. For signs up to 20 sq. inch (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
   b. For signs larger than 20 sq. inch (129 sq. cm), 1/8 inch (3.2 mm) thick.
   c. Engraved legend with white letters on dark gray background.
   d. Self-adhesive.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Hellerman Tyton
2. Ideal Industries, Inc.
3. Panduit Corporation.

B. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Listing Criteria: UL CCN ZODZ; including UL 1565 or UL 62275.

C. UL ZODZ - General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) in accordance with ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

D. UL ZODZ - UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength at 73 deg F (23 deg C) in accordance with ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

E. UL ZODZ - Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) in accordance with ASTM D638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 SELECTION OF COLORS AND IDENTIFICATION MARKINGS

A. Comply with 29 CFR 1910.144 for color identification of hazards, and the following:

1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.
2. Ceiling-mounted hangers, supports, cable trays, and raceways must be finished, painted, or suitably marked safety yellow where less than 7.7 ft (2.3 m) above finished floor.

B. Pipe and Conduit Labeling: Comply with ASME A13.1 and IEEE C2.

C. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

1. Color must be factory applied.
2. Colors for 208Y/120 V Circuits:
    a. Phase A: Black.
    b. Phase B: Red.
    c. Phase C: Blue.
3. Colors for 240 V Circuits:
    a. Phase A: Black.
    b. Phase B: Red.
4. Colors for 480Y/277 V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.

5. Color for Neutral (Grounded Conductor): White or gray.
6. Color for Equipment Ground: Green.
7. Color for Isolated Ground: Green with white stripes.

D. Color-Coding Raceways, Cable Trays, Junction Boxes, and Conductors for Intrinsically-Safe Circuits: Light blue. When used to identify intrinsically-safe circuits, Article 504 of NFPA 70 requires that the color light blue not be used for any other purpose.

E. Color-Coding Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.

F. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends must be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."
4. “FIRE ALARM”
5. “NURSE CALL”.

G. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

H. Locations of Underground Lines: Underground-line warning tape for power and lighting.

I. Vaults, Manholes, Handholes, and Pull and Junction Boxes, 1000 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels to identify phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft (15 m) maximum intervals in straight runs, and at 25 ft (7.6 m) maximum intervals in congested areas.
2. Identify system voltage and system or service type with black letters on orange field.

J. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 90 A and 150 V to Ground: Identify with self-adhesive vinyl tape applied in bands.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft (15 m) maximum intervals in straight runs, and at 25 ft (7.6 m) maximum intervals in congested areas.
2. Identify system voltage and system or service type with black letters on orange field.

K. Conductors to Be Extended in Future: Attach write-on tags or marker tape to conductors and list source.

L. Cover Plates: Label individual cover plates with self-adhesive labels. Place label at top of cover plate. Label cover plate with the following information, in the order listed:

1. Panelboard designation.
2. Colon or dash.
3. Branch circuit number.

M. Workspace Indication: Apply floor marking tape to finished surfaces. Show working clearances in direction of access to live parts. Workspace must comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

N. Equipment Identification Labels:

1. Black letters on white field.
2. Indoor Equipment: Laminated acrylic or melamine plastic sign.
3. Outdoor Equipment: Laminated acrylic or melamine sign.
4. Equipment to Be Labeled:
    a. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
    b. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of self-adhesive, engraved laminated acrylic or melamine label.
    c. Enclosures and electrical cabinets.
    d. Access doors and panels for concealed electrical items.
    e. Switchboards.
    f. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
    g. Emergency system boxes and enclosures.
    h. Enclosed switches.
    i. Enclosed circuit breakers.
    j. Enclosed controllers.
    k. Variable-speed controllers.
    l. Push-button stations.
    m. Power-transfer equipment.
    n. Contactors.
    o. Remote-controlled switches, dimmer modules, and control devices.

p. Uninterruptible power supplies.

O. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 SELECTION OF SIGNS AND HAZARD MARKINGS

A. Comply with 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs.

B. Signs, labels, and tags required for personnel safety must comply with the following standards:

1. Safety Colors: NEMA Z535.1.
2. Facility Safety Signs: NEMA Z535.2.
3. Safety Symbols: NEMA Z535.3.
4. Product Safety Signs and Labels: NEMA Z535.4.
5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

C. Electrical Hazard Warnings:

1. Arc-Flash Hazard Warning: Self-adhesive labels. Comply with NFPA 70E and Section 260573 "Power System Studies" requirements for arc-flash hazard warning labels.
2. Raceways and Cables Carrying Circuits at More Than 1000 V:
   a. Black letters on orange field.
   b. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
3. Multiple Power Sources Warning Legend: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
4. OSHA Workspace Clearance Warning Legend: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 3 FEET MINIMUM."

D. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels or Baked-enamel warning signs.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
   a. Power-transfer switches.
   b. Controls with external control power connections.

E. Operating Instruction Signs: Self-adhesive labels or Baked-enamel warning signs.

F. Emergency Operating Instruction Signs: Self-adhesive labels or Baked-enamel warning signs with white legend on red background with minimum 3/8 inch (10 mm) high letters for emergency instructions at equipment used for power transfer.

3.4 SELECTION OF IDENTIFICATION PRODUCTS FOR COMMUNICATIONS, CONTROL, AUXILIARY, AND LIFE SAFETY SYSTEMS

A. Comply with Section 270528 "Pathways for Communications Systems" and Section 271100 "Communications Equipment Room Fittings."

3.5 INSTALLATION

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes typical for electrical equipment environments specified in Section 018116 "Facility Environmental Requirements" and Section 260010 "Supplemental Requirements for Electrical."

C. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

D. Fasteners for Labels and Signs: Self-tapping, stainless steel screws or stainless steel machine screws with nuts and flat and lock washers.

E. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

F. Install identifying devices before installing acoustical ceilings and similar concealment.

G. Verify identity of item before installing identification products.

H. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

I. Apply identification devices to surfaces that require finish after completing finish work.

J. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.

L. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to location and substrate.

M. Snap-Around Labels: Secure tight to surface at location with high visibility and accessibility.

N. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.

O. Snap-Around Color-Coding Bands: Secure tight to surface at location with high visibility and accessibility.

P. Heat-Shrink, Preprinted Tubes: Secure tight to surface at location with high visibility and accessibility.

Q. Marker Tapes: Secure tight to surface at location with high visibility and accessibility.

R. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

S. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

T. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's instructions.

U. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape not less than 12 inch (300 mm) directly above cables or raceways buried 18 inch (450 mm) or more below grade. Use multiple tapes where width of multiple lines installed in common trench or concrete envelope exceeds 16 inch (400 mm) overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

V. Metal Tags:

1. Place in location with high visibility and accessibility.
2. Secure using general-purpose or plenum-rated cable ties.

W. Nonmetallic Preprinted Tags:

1. Place in location with high visibility and accessibility.
2. Secure using general-purpose or plenum-rated] cable ties.

X. Write-on Tags:

1. Place in location with high visibility and accessibility.
2. Secure using general-purpose, UV-stabilized or plenum-rated cable ties.

Y. Baked-Enamel Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

Z. Metal-Backed Butyrate Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

AA. Laminated Acrylic or Melamine Plastic Signs: Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.

END OF SECTION 260553

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SECTION 260573

POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. The Work of this Section Includes:

1. Short-circuit study.
2. Overcurrent protective device coordination study.
3. Load-flow and voltage-drop study.
4. Arc-flash hazard study.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.

1.2 DEFINITIONS

A. Digital Twin: The digital representation of a real-world entity, concept, or notion, either physical or perceived.

1.3 ACTION SUBMITTALS

A. Product Data: For power system analysis software to be used for studies.

1. Product Certificates: For power system study software applications, include certificate stating compliance with specified requirements, signed by software manufacturer.

B. Power System Study Reports:

1. Submit reports after approval of system protective devices submittals. Submittals must be in digital form.
2. Submit short-circuit study input data, including completed computer-program input data sheets.
3. Submit coordination study input data, including completed computer-program input data sheets.
    a. Submit load-flow, voltage-drop, and motor-starting data with coordination study.
4. Submit arc-flash study input data, including completed computer-program input data sheets.
5. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

6. Submit revised one-line diagram, reflecting field investigation results and results of short-circuit study.

C. Data files for studies in format compatible with Owner's power system analysis software.

D. Digital-twin models.

1.4 QUALITY ASSURANCE

A. Submittals for power system studies must be signed and sealed by qualified electrical professional engineer responsible for their preparation.

B. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.

C. Software algorithms must comply with requirements of standards and guides specified in this Section.

D. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

A. Standard Features:

1. Power System Analysis:

a. Power-systems-analysis software applications must have analytical capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 3002 series standards.

b. Computer software application must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.

c. Computer software application must be designed to perform arc-flash analysis or have function, component, or add-on module designed to perform arc-flash analysis.

2. Analysis Standards:

a. Short-Circuit Current Analysis: In accordance with IEEE 3002.3.

b. Device Coordination Analysis: In accordance with IEEE 3004.3 and IEEE 3004.5.

c. Load-Flow Analysis: In accordance with IEEE 3002.2.

d. Motor-Starting Analysis: In accordance with IEEE 3002.7.

e. Harmonic Analysis: In accordance with IEEE 3002.8.

f. Transient Stability Analysis: In accordance with IEEE P3002.9.

g. Arc-Flash Hazard Analysis: In accordance with IEEE 1584.

3. Capable of printing arc-flash hazard warnings for equipment on **vinyl**, weather- and UV-resistant, pressure-sensitive adhesive labels complying with NFPA 70E.
    a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard study:
        1) Equipment designation.
        2) Nominal voltage.
        3) Protection boundaries.
            a) Arc-flash boundary.
            b) Restricted approach boundary.
            c) Limited approach boundary.
        4) Arc-flash PPE category.
        5) Required minimum arc rating of PPE in Cal/cm squared.
        6) Available incident energy.
        7) Working distance.
        8) Engineering report number, revision number, and issue date.

B. Other Available Features Required by the Project:
    1. Simultaneous faults.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Collect and analyze data for power system studies.
    1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies to Architect's attention.
    2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
    3. Gather and tabulate required input data to support power system studies. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 3002 series standards as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:
        a. Product data for the Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

b. Electrical power utility impedance at service.
c. Power sources and ties.
d. Short-circuit current at each system bus (three phase and line to ground).
e. Full-load current of loads.
f. Voltage level at each bus.
g. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
h. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
i. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
j. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
k. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
l. Maximum demands from service meters.
m. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
n. Motor horsepower and NEMA MG 1 code letter designation.
o. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
p. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
q. Derating factors.

3.2 PREPARATION

A. Preparation of Data for Short-Circuit Study:
1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Architect's attention.
2. For equipment included as Work on the Project, use characteristics submitted under provisions of action submittals and information submittals for the Project.
3. Prepare one-line diagram of modeled power system, showing the following:
a. Protective device designations and ampere ratings.
b. Conductor types, sizes, and lengths.
c. Transformer kVA and voltage ratings.

d. Motor and generator designations and kVA ratings.

e. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.

f. Derating factors and environmental conditions.

g. Revisions to electrical equipment required by study.

B. Preparation of Data for Overcurrent Protective Device Coordination Study:

1. Prepare data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, indicating the following:

a. Special load considerations, including starting inrush currents and frequent starting and stopping.

b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

d. Generator thermal-damage curve.

e. Ratings, types, and settings of utility company's overcurrent protective devices.

f. Special overcurrent protective device settings or types stipulated by utility company.

g. Time-current-characteristic curves of devices indicated to be coordinated.

h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.

k. Identify series-rated interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

2. Examine the Project's overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.

3. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

C. Preparation of Data for Arc-Flash Hazard Study:

1. Assemble data from short-circuit study and overcurrent protective device coordination study.
2. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.3 SHORT-CIRCUIT STUDY

A. Base study on device characteristics supplied by device manufacturer.

B. Extent of electrical power system to be studied is indicated on Drawings.

C. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240 V AC or less when supplied by single transformer smaller than 125 kVA.

D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

E. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement to address asymmetrical requirements of interrupting equipment.

F. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

G. Include in report identification of protective device applied outside its capacity.

3.4 OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

A. Base study on device characteristics supplied by device manufacturer.

B. Extent of electrical power system to be studied is indicated on Drawings.

C. Begin analysis at service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240 V AC or less when supplied by single transformer smaller than 125 kVA.

D. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for the Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

E. Transformer Primary Overcurrent Protective Devices:

1. Device must not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads in accordance with IEEE C57.96 if required by unusual loading or emergency conditions.
2. Device settings must protect transformers in accordance with IEEE C57.12.00, for fault currents.

F. Motor Protection:

1. Select protection for low-voltage motors in accordance with IEEE 3004.8 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V in accordance with IEEE 620.

G. Conductor Protection: Protect cables against damage from fault currents in accordance with ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 3004.7. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

H. Generator Protection: Select protection in accordance with manufacturer's published instructions and IEEE C37.102.

I. Include AC fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase AC systems. Also account for fault-current DC decrement, to address asymmetrical requirements of interrupting equipment.

J. Include coordination of ground-fault protection devices.

K. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at equipment indicated on one-line diagram.

1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.

L. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.

2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Application of series-rated devices must be recertified, complying with requirements in NFPA 70.
4. Include in report identification of protective device applied outside its capacity.

3.5 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform load-flow and voltage-drop study to determine steady-state loading profile of system. Analyze power system performance two times as follows:
1. Determine load flow and voltage drop based on full-load currents.
2. Determine load flow and voltage drop based on 80 percent of design capacity of load buses.
3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded, or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.6 MOTOR-STARTING STUDY – NOT USED

3.7 ARC-FLASH HAZARD STUDY

A. Comply with NFPA 70E, including Annex D, for arc-flash hazard study.
B. Preparatory Studies: Obtain short-circuit study and overcurrent protective device coordination study results prior to starting arc-flash hazard study.
C. Calculate maximum and minimum contributions of fault-current size.
1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current in accordance with NFPA 70E recommendations.
4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.
D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
E. Include medium- and low-voltage equipment locations.
F. Calculate limited, restricted, and prohibited approach boundaries for each location.
G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must account for

changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:

1. Fault contribution from induction motors must not be considered beyond three to five cycles.
2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).

H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:

1. When circuit breaker is in separate enclosure.
2. When line terminals of circuit breaker are separate from work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.8 POWER SYSTEM STUDY REPORTS

A. Preparation of Power System Study Reports: Prepare and submit the following:

1. Short-Circuit Study Report Contents:
   a. Executive summary of study findings.
   b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
   c. One-line diagram of modeled power system, showing the following:
      1) Protective device designations and ampere ratings.
      2) Conductor types, sizes, and lengths.
      3) Transformer kVA and voltage ratings.
      4) Motor and generator designations and kVA ratings.
      5) Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
      6) Derating factors and environmental conditions.
      7) Revisions to electrical equipment required by study.
   d. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.
   e. Short-Circuit Study Input Data:
      1) One-line diagram of system being studied.
      2) Power sources available.
      3) Manufacturer, model, and interrupting rating of protective devices.

4) Conductors.

5) Transformer data.

f. Protective Device Evaluation:

1) Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.

2) Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.

3) For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

4) For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.

5) Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

g. Short-Circuit Study Output Reports:

1) Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.

b) Calculated fault-current magnitude and angle.

c) Fault-point X/R ratio.

d) Equivalent impedance.

2) Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.

b) Calculated symmetrical fault-current magnitude and angle.

c) Fault-point X/R ratio.

d) Calculated asymmetrical fault currents based on fault-point X/R ratio; based on calculated symmetrical value multiplied by 1.6; and based on calculated symmetrical value multiplied by 2.7.

3) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a) Voltage.

b) Calculated symmetrical fault-current magnitude and angle.
c) Fault-point X/R ratio.
d) No AC Decrement (NACD) ratio.
e) Equivalent impedance.
f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

2. Overcurrent Protection Device Coordination Study Report Contents:
a. Executive summary of study findings.
b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
c. One-line diagram of modeled power system, showing the following:
1) Protective device designations and ampere ratings.
2) Conductor types, sizes, and lengths.
3) Transformer kVA and voltage ratings.
4) Motor and generator designations and kVA ratings.
5) Switchgear, switchboard, motor-control center, and panelboard designations.
6) Revisions to electrical equipment required by study.
d. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.
1) Phase and Ground Relays:
a) Device tag.
b) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
c) Recommendations on improved relaying systems, if applicable.
2) Circuit Breakers:
a) Adjustable pickups and time delays (long time, short time, and ground).
b) Adjustable time-current characteristic.
c) Adjustable instantaneous pickup.
d) Recommendations on improved trip systems, if applicable.
3) Fuses: Show current rating, voltage, and class.

e. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:

1) Device tag and title, one-line diagram with legend identifying portion of system covered.

2) Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

3) Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

4) Plot the following listed characteristic curves, as applicable:

a) Power utility's overcurrent protective device.

b) Medium-voltage equipment overcurrent relays.

c) Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.

d) Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.

e) Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.

f) Cables and conductors damage curves.

g) Ground-fault protective devices.

h) Motor-starting characteristics and motor damage points.

i) Generator short-circuit decrement curve and generator damage point.

j) Largest feeder circuit breaker in each motor-control center and panelboard.

5) Maintain selectivity for tripping currents caused by overloads.

6) Maintain maximum achievable selectivity for tripping currents caused by overloads on series-rated devices.

7) Provide adequate time margins between device characteristics such that selective operation is achieved.

8) Comments and recommendations for system improvements.

3. Arc-Flash Hazard Study Report Contents:

a. Executive summary of study findings.

b. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

c. One-line diagram, showing the following:

1) Protective device designations and ampere ratings.

2) Conductor types, sizes, and lengths.

3) Transformer kVA and voltage ratings, including derating factors and environmental conditions.

4) Motor and generator designations and kVA ratings.

5) Switchboard, motor-control center, panelboard designations, and ratings.

d. Short-circuit study output data.

e. Overcurrent protective device coordination study report contents.

f. Arc-Flash Study Output Reports:

1) Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:

a) Voltage.

b) Calculated symmetrical fault-current magnitude and angle.

c) Fault-point X/R ratio.

d) No AC Decrement (NACD) ratio.

e) Equivalent impedance.

f) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.

g) Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

g. Incident Energy and Flash Protection Boundary Calculations:

1) Arcing fault magnitude.

2) Protective device clearing time.

3) Duration of arc.

4) Arc-flash boundary.

5) Restricted approach boundary.

6) Limited approach boundary.

7) Working distance.

8) Incident energy.

9) Hazard risk category.

10) Recommendations for arc-flash energy reduction.

h. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

3.9 DIGITAL-TWIN MODELING – NOT USED

3.10 FIELD ADJUSTMENT FOR DEVICE COORDINATION

A. Adjust relay and protective device settings in accordance with recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with **short-circuit and** protective device coordination studies.

C. Testing and adjusting must be by qualified low-voltage electrical testing and inspecting agency.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

3.11 WARNING LABELING OF ARC-FLASH HAZARDS

A. Apply **one** arc-flash label on front cover **of each section of equipment** for each equipment included in study, including each piece of equipment listed below:

1. Switchboards.
2. Panelboards.
3. Low voltage transformers.
4. Safety switches.
5. Control panels.

B. Base arc-flash label data on highest values calculated at each location.

C. Machine print warning labels with no handwritten or field-applied markings.

D. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.

E. Indicate on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

END OF SECTION 260573

SECTION 260923

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Outdoor photoelectric switches.
3. Business occupancy and vacancy sensors.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding of lighting control devices referenced by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies hangers and supports referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 262726 "Wiring Devices", Section 262726.11 "General-Use Switches, Dimmer Switches, and Fan-Speed Controller Switches" for wall-box dimmers and manual light switches.

1.2 DEFINITIONS

A. BCELTS: Branch circuit emergency lighting transfer switch.
B. DPDT: Double pole double throw.
C. DPST: Double pole single throw.
D. N.C.: Normally closed.
E. N.O.: Normally open.
F. PIR: Passive infrared.
G. SPDT: Single pole double throw.
H. SPST: Single pole single throw.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.

a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.

b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.

c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are unacceptable for submitted product.

2. Include manufacturer's sample extended warranty language.

B. Shop Drawings: Prepare and submit the following:

1. Show installation details for the following:

a. Occupancy sensors.

b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.

3. Diagrams for power, signal, and control wiring.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.

2. Field reports for software and firmware upgrades.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

B. Software and firmware service agreement.

1.6 QUALIFICATIONS – NOT USED

1.7 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that installed lighting control devices perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that lighting control devices perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Failures include, but are not limited to, the following:
   a. Faulty operation of lighting control software.
   b. Faulty operation of lighting control devices.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements:

1. Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
2. Must comply with CCR Title 24.

2.2 TIME SWITCHES

A. UL WGZR - Electronic Time Switch:

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Clock-Operated Switches: UL CCN WGZR, including UL 917.
3. Standard Features:
   a. Contact Configuration: SPST or DPDT.
   b. Contact Rating: 30 A inductive or resistive, 240 V(ac).
   c. Programs:
      1) Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
      2) Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
   d. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
   e. Astronomic Time: All channels.

f. Automatic daylight savings time changeover.

g. Battery Backup: Not less than seven days' reserve, to maintain schedules and time clock.

B. UL WGZR - Electromechanical-Dial Time Switch:

1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Clock-Operated Switches: UL CCN WGZR, including UL 917.

3. Standard Features:

a. Contact Configuration: SPST.

b. Contact Rating: 30 A inductive or resistive, 240 V(ac).

c. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.

d. Astronomic time dial.

e. Eight-Day Program: Uniquely programmable for each weekday and holidays.

f. Skip-a-day mode.

g. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of **16** hours.

C. UL WGZR - Digital Timer Light Switch:

1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Clock-Operated Switches: UL CCN WGZR, including UL 917.

3. Standard Features:

a. Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in [**10**] [**20**]-minute increments.

b. Rated 960 W at 120 V(ac) for tungsten lighting, 10 A at 120 V(ac) or 10 A at 277 V(ac) for fluorescent or LED lighting, and 1/4 hp at 120 V(ac).

c. Standards: Comply with UL 20.

d. Integral relay for connection to BAS.

e. Voltage: Dual voltage - 120 and 277 V.

f. Color: White.

g. Faceplate: Color matched to switch.

2.3 OUTDOOR PHOTOELECTRIC SWITCHES

A. UL WJFX - Solid-State Outdoor Photoelectric Switch, Flexible:

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
3. Standard Features:
   a. Solid state, with SPST or DPST dry contacts rated for 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; and compatible with drivers and LED lamps.
   b. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
   c. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
   d. Time Delay: Fifteen-second minimum, to prevent false operation.
   e. Surge Protection: Metal-oxide varistor.
   f. Mounting: Twist lock complies with ANSI C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
   g. Failure Mode: Luminaire stays ON.

B. UL WJFX - Solid-State Outdoor Photoelectric Switch, Luminaire-Mounted:

1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Plug-in, Locking-Type Photocontrols: UL CCN WJFX, including UL 773.
3. Standard Features:
   a. Solid state, with SPST or DPST dry contacts rated for 1800 VA inductive, to operate connected load, and compatible with CFL and LED lamps.
   b. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
   c. Time Delay: Thirty-second minimum, to prevent false operation.

d. Lightning Arrester: Air-gap type.

e. Mounting: Twist lock complying with ANSI C136.10, with base.

f. Failure Mode: Luminaire stays ON.

2.4 DAYLIGHT-HARVESTING CONTROLS – NOT USED

2.5 BUSINESS OCCUPANCY AND VACANCY SENSORS

A. Passive-Infrared (PIR) Occupancy or Vacancy Sensor:

1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:

a. Photoelectric Controls: UL CCN WJCT, including UL 773A.

b. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.

c. Intrusion Detection Units: UL CCN ANSR, including UL 639.

3. Standard Features:

a. Wall or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.

b. Integrated or Separate power pack.

c. Hardwired connection to switch.

d. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A or Sensor is powered from the power pack.

e. Power: Line voltage.

f. Power Pack: Dry contacts rated for 20 A LED load at 120 and 277 V(ac), for 13 A tungsten at 120 V(ac), and for 1 hp at 120 V(ac). Sensor has 24 V(dc), 150 mA, Class 2 power source.

g. Mounting:

1) Sensor: Suitable for mounting in any position in a standard device box or outlet box.

2) Relay: Externally mounted through a 1/2 inch (13 mm) knockout in a standard electrical enclosure.

3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

h. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.

i. Bypass Switch: Override the "on" function in case of sensor failure.

j. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); turn lights off when selected lighting level is present.

k. Detector Sensitivity: Detect occurrences of 6 inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch (23 200 sq. mm).

1) Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft (93 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.

2) Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 ft (27.4 m) when mounted on a 10 ft (3 m) high ceiling.

3) Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft (110 sq. m) when mounted 48 inch (1200 mm) above finished floor.

4. Operation:

a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

B. Dual-Technology, Passive-Infrared (PIR) and Ultrasonic, Occupancy or Vacancy Sensor:

1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:

a. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.

b. Appliance Controls: UL CCN ATNZ, including UL 60730-1.

c. Intrusion Detection Units: UL CCN ANSR, including UL 639.

3. Standard Features:

a. Wall or Ceiling]-mounted, solid-state indoor occupancy and vacancy sensors.

b. Separate power pack.

c. Hardwired connection to switch.

d. Sensitivity Adjustment: Separate for each sensing technology.

e. Detector Sensitivity: Detect occurrences of 6 inch (150 mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. inch (23 200 sq. mm), and detect a person of average size and weight moving not less than 12 inch (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inch/s (305 mm/s).

1) Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft (93 sq. m) when mounted on a 96 inch (2440 mm) high ceiling.

2) Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 sq. ft (110 sq. m) above finished floor.

4. Operation:

a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

c. Combination Sensor: Unless otherwise indicated, sensor must be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

C. Wall-Switch Occupancy Sensor:

1. Source Limitations: Obtain products from single manufacturer.

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for one of the following UL product categories:

a. Photoelectric Controls: UL CCN WJCT, including UL 773A.

b. Energy Management Equipment: UL CCN PAZX, including UL 916 or UL 60730-1.

c. Intrusion Detection Units: UL CCN ANSR, including UL 639.

3. Standard Features:

a. Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in single gang switchbox.

1) Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2) Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
3) Switch Rating: Not less than 800 VA LED load at 120 V, 1200 VA LED load at 277 V, and 800 W incandescent.

b. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft (196 sq. m).
c. Sensing Technology: Dual technology - PIR and ultrasonic.
d. Switch Type: Single pole, field-selectable automatic "on," or manual "on," automatic "off."
e. Capable of controlling load in three-way application.
f. Voltage: Dual voltage - 120 and 277 V.
g. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lx). Switch prevents lights from turning on when light level is higher than set point of sensor.
h. Time Delay:
1) Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
2) Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
i. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
j. Color: Ivory.
k. Faceplate: Color matched to switch.

2.6 STORAGE OCCUPANCY SENSORS – NOT USED

2.7 OUTDOOR MOTION SENSORS – NOT USED

2.8 INDUSTRIAL CONTROL SWITCHES

A. Lighting Contactor:
1. Source Limitations: Obtain products from single manufacturer.
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
a. Industrial Control Switches: UL CCN NRNT, including UL 508.
3. Standard Features:

a. Electrically operated and mechanically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2.

b. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush driver (driver with 15 percent or less THD of normal load current).

c. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.

d. Enclosure Rating: Comply with UL 50E.

e. Provide with control and pilot devices as indicated on the Drawings, matching the enclosure rating specified for the enclosure.

f. Interface with DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.

1) Monitoring: On-off status, Building Management Panel.

2) Control: On-off operation, Building Management Panel.

2.9 EMERGENCY LIGHTING CONTROLS – NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

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

3.2 SELECTION OF CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than 22 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than 16 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 INSTALLATION OF LIGHTING CONTROL DEVICES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:
   1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
   2. Electrical Maintenance: NFPA 70B.
   3. Electrical Safety: NFPA 70E.
   4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
   5. Communications Work: BICSI N1.
   6. Life Safety and Means of Egress Work: NFPA 101.
   7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
   8. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:
   1. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
   2. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's instructions.
   3. Installation of Industrial Control Switches: Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.
   4. Installation of Wiring:
      a. Conduit: Minimum conduit size is 1/2 inch (13 mm).
      b. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's published instructions.
      c. Size conductors in accordance with lighting control device manufacturer's published instructions unless otherwise indicated.
      d. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

D. Interfaces with Other Work:
   1. Identification: Provide labels for lighting control devices and associated electrical equipment.
      a. Identify field-installed conductors, interconnecting wiring, and components.
      b. Label each enclosure with engraved metal or laminated-plastic nameplate.
      c. Identify controlled circuits in lighting contactors.

d. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

e. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Nonconforming Work:

1. Lighting control devices will be considered defective if they do not pass tests and inspections.

2. Remove and replace defective units and retest.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

D. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project site.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to the Project site during other-than-normal occupancy hours for this purpose. Some of the Work may be required during hours of darkness.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.

2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 CLOSEOUT ACTIVITIES

A. Demonstration:

1. With assistance from factory-authorized service representatives, demonstrate to Owner's maintenance and clerical personnel how to operate the following systems and equipment:

a. Lighting control devices.

B. Training:

1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:
   a. How to adjust, operate, and maintain lighting control devices.

3.7 MAINTENANCE

A. Software and Firmware Service Agreement:
   1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software support for two years.
   2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Verify upgrading software includes operating system and new or revised licenses for using software.
      a. Upgrade Notice: Not less than 30 days; to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
   3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 260923

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SECTION 262213

LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
   a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
   b. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of field connections.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation and testing instructions issued to Installer by manufacturer for the following:

1. Transformer temporary heating, working clearances, anchoring, torque values, and insulation-resistance testing.

B. Source quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in warm, dry, and temperature-stable location in original shipping packaging.

C. Temporary Heating: Apply temporary heat in accordance with manufacturer's published instructions within enclosure of ventilated-type units, throughout periods during which equipment is not energized and when transformer is not in space that is continuously under normal control of temperature and humidity.

D. Handling: Follow manufacturers' instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 OWNER-FURNISHED PRODUCTS – NOT USED

2.2 EXISTING PRODUCTS – NOT USED

2.3 MANUFACTURERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton.

b. General Electric Company.

c. Siemens Industry, Inc. Energy Management Division.

d. Square D; by Schneider Electric.

B. Source Limitations: Obtain each type of transformer from single source from single manufacturer.

2.4 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.

B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.

2. Marked as compliant with DOE 2016 efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.

D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside transformer enclosure.

2.5 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
   1. One leg per phase.
   2. Core volume must allow efficient transformer operation at 10 percent above nominal tap voltage.
   3. Grounded to enclosure.

C. Coils: Continuous windings without splices except for taps.
   1. Coil Material: Copper.
   2. Internal Coil Connections: Brazed or pressure type.
   3. Terminal Connections: Welded.

D. Encapsulation: Transformers smaller than 30 kVA must have core and coils completely resin encapsulated.

E. Enclosure: Ventilated.
   1. Core and coil must be encapsulated within resin compound to seal out moisture and air.
   2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
   3. Wiring Compartment: Sized for conduit entry and wiring installation.
   4. Environmental Protection:
      a. Indoor: UL 50E, Type 2.
   5. Finish Color: Gray weather-resistant enamel.

F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

G. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of 115 deg C rise above 40 deg C ambient temperature.

H. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

I. K-Factor Rating: Transformers indicated to be K-factor rated must comply with UL 1561 requirements for nonsinusoidal load current-handling capability to degree defined by designated K-factor.
   1. Unit may not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding indicated insulation class in 40 deg C maximum ambient and 24-hour average ambient of 30 deg C.
   2. Indicate value of K-factor on transformer nameplate.

3. Unit must comply with requirements of DOE 2016 efficiency levels when tested in accordance with NEMA TP 2 with K-factor equal to one.

J. Electrostatic Shielding: Windings must have independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding shield.

K. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.

L. Wall Brackets: Manufacturer's standard brackets.

M. Low-Sound-Level Requirements: Maximum sound levels when factory tested in accordance with IEEE C57.12.91, as follows:

1. 9.01 to 30.00 kVA: 45 dB(A-weighted).
2. 30.01 to 50.00 kVA: 45 dB(A-weighted) for K-factors of 1, 4, and 9.
3. 50.01 to 150.00 kVA: 50 dB(A-weighted) for K-factors of 1, 4, and 9.

2.6 IDENTIFICATION

A. Nameplates:

1. Engraved, laminated-acrylic or melamine plastic signs for distribution transformers, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."
2. Self-adhesive label for distribution transformers. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

2.7 SOURCE QUALITY CONTROL

A. Testing Administrant: Engage qualified electrical testing agency to evaluate transformer.

B. Factory Tests and Inspections: Test and inspect assembled system, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, in accordance with IEEE C57.12.01 and IEEE C57.12.91 before delivering to site. Affix label with name and date of manufacturer's certification of system compliance on control units.

1. Resistance measurements of windings at rated voltage connections and at tap connections.
2. Ratio tests at rated voltage connections and at tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.
5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.

7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:
    a. Line-side to ground.
    b. Load-side to ground.
    c. Line-side to load-side.
9. Temperature tests.
10. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

C. Nonconforming Work:
1. System equipment that does not pass tests and inspections will be considered defective.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at location of transformer.

E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.

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

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
2. Brace wall-mounted transformers as specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems.

B. Install transformers level and plumb on concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions, seismic requirements applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base in accordance with manufacturer's published instructions.

E. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Prepare testing and inspection reports.

B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections:

1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:

a. Visual and Mechanical Inspection.

1) Inspect physical and mechanical condition.

2) Inspect anchorage, alignment, and grounding.

3) Verify that resilient mounts are free and that shipping brackets have been removed.

4) Verify that unit is clean.

5) Perform specific inspections and mechanical tests recommended by manufacturer.

6) Verify that as-left tap connections are as specified.

7) Verify presence of surge arresters and that their ratings are as specified.

b. Electrical Tests:

1) Measure resistance at windings, taps, and bolted connections.

2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.

3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.

4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

D. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.

E. Nonconforming Work:

1. Transformer will be considered defective if it does not pass tests and inspections.

2. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Assemble and submit test and inspection reports.

G. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.5 ADJUSTING

A. Record transformer secondary voltage at unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.7 MAINTENANCE

A. Infrared Scanning: Two months after Substantial Completion, perform infrared scan of transformer connections.

1. Use infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2. Perform two follow-up infrared scans of transformers, one at four months and another at 11 months after Substantial Completion.
3. Prepare certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 262213

SECTION 262416

PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Panelboards.
2. Disconnecting and overcurrent protective devices.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional abbreviations, definitions, submittals, qualifications, testing agencies, and other requirements applicable to the Work for electrical, communications, and electronic safety and security systems on Project, including wiring methods.
4. Section 260529 "Hangers and Supports for Electrical Systems" specifies concrete bases and supports for panelboards installed by this Section.
5. Section 260548 "Vibration and Seismic Controls for Electrical Systems" specifies seismic control devices, mounting devices, and anchoring devices installed by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
7. Section 260573 "Power System Studies" specifies short-circuit current studies, overcurrent protective device coordination studies, and arc-flash hazard analysis studies.
8. Section 260913 "Electrical Power Monitoring" specifies power monitoring and control systems installed by this Section.
9. Section 262813 "Fuses" specifies fuses and spare-fuse cabinets installed by this Section.
10. Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" specifies Type 1 and Type 2 surge protective devices installed by this Section.

1.2 DEFINITIONS

A. ATS: Acceptance testing specification.

B. GFCI: Ground-fault circuit interrupter

C. GFPE: Ground-fault protection equipment.

D. HID: High-intensity discharge.

E. MCCB: Molded-case circuit breaker.

F. SPD: Surge protective device.

G. VPR: Voltage protection rating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. In addition to information identified in Section 013300 "Submittal Procedures," submit the following:

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
2. Include manufacturer's sample extended warranty language.
3. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
4. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment:

1. Include dimensioned plans, elevations, sections, and details.
2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

C. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

B. Manufacturer's published instructions.

C. Qualification Data: For testing agency.

D. Field Reports:

1. Manufacturer's field reports for field quality-control support.
2. Field reports for voltage monitoring and adjusting.
3. Field reports for infrared scanning.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

B. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.

1.7 QUALIFICATIONS

A. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.

1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

B. Handle and prepare panelboards for installation in accordance with NECA 407.

1.9 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed panelboards perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED – NOT USED

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED – NOT USED

2.3 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Fabricate and test panelboards in accordance with IEEE 344 to withstand seismic forces specified in Section 018123 "Facility Seismic and Wind Criteria."

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Comply with NEMA PB 1.

E. Enclosures: Flush and Surface -mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.
    a. Indoor Dry and Clean Locations: UL 50E, Type 1.
    b. Outdoor Locations: UL 50E, Type 3R.
2. Height: 7 ft (2.13 m) maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims must cover live parts and may have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims must cover live parts and may have no exposed hardware.
5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
7. Finishes:
    a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
    b. Back Boxes: Galvanized steel.
    c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.

F. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
   a. Plating must run entire length of bus.
   b. Bus must be fully rated for entire length.
2. Interiors must be factory assembled into unit. Replacing switching and protective devices may not disturb adjacent units or require removing main bus connectors.
3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

G. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
2. Terminations must allow use of 75 deg C rated conductors without derating.
3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
4. Main and Neutral Lugs: Mechanical type, with lug on neutral bar for each pole in panelboard.
5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with lug on bar for each pole in panelboard.

H. Quality-Control Label: Panelboards or load centers must be labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards or load centers must have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

I. Future Devices: Panelboards or load centers must have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
1. Percentage of Future Space Capacity: See plans.

J. Panelboard Short-Circuit Current Rating:
1. Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for 100 percent interrupting capacity.
   a. Panelboards and overcurrent protective devices rated 240 V or less must have short-circuit ratings as shown on Drawings, but not less than 10 000 A(rms) symmetrical.
   b. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V must have short-circuit ratings as shown on Drawings, but not less than 14 000 A(rms) symmetrical.

2.4 PANELBOARDS

A. UL QEUY - Distribution Panelboard:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton.
   b. General Electric Company; GE Energy Management – Electrical Distribution.
   c. Siemens Industry, Inc. Energy Management Division.
   d. Square D; by Schneider Electric.
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Distribution Type Panelboards: UL CCN QEUY; including UL 67 and NEMA PB 1.
4. Standard Features:
   a. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
      1) For doors more than 36 inch (914 mm) high, provide two latches, keyed alike.
   b. Mains: Circuit breaker or Lugs only as indicated in schedules.
      1) Location: Top or Bottom to accommodate incoming feeder.
      2) Main Breaker: Main lug interiors up to 400 A must be field convertible to main breaker.
   c. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
   d. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.
5. Other Available Features Required by Project:
   a. Surge Suppression: Factory installed as integral part of indicated panelboards on all panelboards rated 400 amperes and larger, complying with UL 1449 SPD Type 2.
   b. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure.
   c. Do not mount neutral bus in gutter.
   d. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   e. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

B. UL QEUY - Lighting and Appliance Branch-Circuit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton.
   b. General Electric Company; GE Energy Management – Electrical Distribution.
   c. Siemens Industry, Inc. Energy Management Division.
   d. Square D; by Schneider Electric.
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Lighting and Appliance Branch-Circuit Type Panelboards: UL CCN QEUY; including UL 67 and NEMA PB 1.
4. Standard Features:
   a. Mains: Circuit breaker or lugs only as scheduled. Individual mains. Branch mains prohibited.
      1) Location: Top or Bottom to accommodate incoming feeder.
      2) Main Breaker: Main lug interiors up to 400 A must be field convertible to main breaker.
   b. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
5. Other Available Features Required by Project:
   a. Surge Suppression: Factory installed as integral part of indicated panelboards, complying with UL 1449 SPD Type 2.
   b. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure.
   c. Do not mount neutral bus in gutter.
   d. Feed-Through Lugs: **Mechanical** type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   e. Subfeed (Double) Lugs: **Mechanical** type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   f. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door must permit full access to panel interior. Inner door must permit access to breaker operating handles and labeling, but current carrying terminals and bus must remain concealed.

g. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.

1) Column-Type Panelboard Doors: Concealed hinges secured with multipoint latch with tumbler lock; keyed alike.

2.5 Source Limitations: DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company; GE Energy Management – Electrical Distribution.
3. Siemens Industry, Inc. Energy Management Division.
4. Square D; by Schneider Electric.

B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:
   a. Inverse time-current element for low-level overloads.
   b. Instantaneous magnetic trip element for short circuits.
   c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers (REQUIRED FOR ALL BRANCH AND MAIN BREAKERS IN MAIN SERVICE PANELBOARD AND EMERGENCY DISTRIBUTION PANELBOARD PER NEC 517:
   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event must be recorded with type, phase, and magnitude of fault that caused trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long- and short-time adjustments.
      4) Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6 mA trip).
5. GFPE Circuit Breakers: Class B ground-fault protection (30 mA trip).
6. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240 V, single-pole configuration.
7. Subfeed Circuit Breakers: Vertically mounted.
8. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
   f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   g. Shunt Trip: [**120 V**] trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   h. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
   i. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
   j. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
   k. Rating Plugs: Three-pole breakers with ampere ratings greater than 225 A shall have interchangeable rating plugs or electronic adjustable trip units.
   l. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
   m. Multipole units enclosed in single housing with single handle.

2.6 MAINTENANCE MATERIAL ITEMS

A. Spare Parts: Furnish to Owner spare parts, for repairing panelboards and related equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
   1. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and GFPE Types: Two spares for each panelboard.

B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to panelboards and related equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:

1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
2. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.

B. Receive, inspect, handle, and store panelboards in accordance with NECA 407.

C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.

D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

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

3.2 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Panelboards: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NECA 407.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Equipment Mounting:
   a. Install floor-mounted panelboards on cast-in-place concrete equipment base(s).
   b. Attach panelboard to vertical finished or structural surface behind panelboard.
   c. Mount surface-mounted panelboards to steel slotted supports 1-1/4 inch (32 mm) in depth. Orient steel slotted supports vertically.
   d. Provide seismic control devices.
2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

3. Provide mounting and anchoring devices.
4. Mount top of trim 7.5 ft (2.3 m) above finished floor unless otherwise indicated.
5. Mount panelboard cabinet plumb and rigid without distortion of box.
6. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
7. Install overcurrent protective devices and controllers not already factory installed.
   a. Set field-adjustable, circuit-breaker trip ranges.
   b. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver in accordance with manufacturer's published instructions.
8. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
9. Install filler plates in unused spaces.
10. Stub four 1 inch (25 mm) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in future. Stub four 1 inch (25 mm) empty conduits into raised floor space or below slab not on grade.
11. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
12. Mount spare fuse cabinet in accessible location.

D. Interfaces with Other Work:
1. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components.
B. Install warning signs.
C. Panelboard Nameplates: Label each panelboard with nameplate.
D. Device Nameplates: Label each branch circuit device in power panelboards with nameplate.
E. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles must be located on interior of panelboard door.
F. Breaker Labels: Faceplate must list current rating, UL and IEC certification standards, and AIC rating.
G. Circuit Directory:

1. Provide directory card inside panelboard door, mounted in metal frame with transparent protective cover.
    a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
2. Provide computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
    a. Circuit directory must identify specific purpose with detail sufficient to distinguish it from other circuits.
3. Create directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

3.4 FIELD QUALITY CONTROL

A. Administrant for Low-Voltage Electrical Tests and Inspections:
1. Owner Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified low-voltage electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Field tests and inspections must be witnessed by authorities having jurisdiction.

D. Tests and Inspections:
1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Perform optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Nonconforming Work:

1. Panelboards will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

F. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

1. Include certified report that identifies panelboards included and that describes scanning results, with comparisons of two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

G. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within panelboard, may not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature in accordance with manufacturer's published instructions.

END OF SECTION 262416

SECTION 262719

MULTI-OUTLET ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Floor-mounted, recessed metal raceway multi-outlet assemblies.
2. Indoor service poles.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
3. Section 260533.13 "Conduits for Electrical Systems" and Section 260533.23 "Surface Raceways for Electrical Systems" for raceways.
4. Section 260533.16 "Boxes and Covers for Electrical Systems" for floor boxes and covers.
5. Section 262726 "Wiring Devices" for receptacles and switches.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Wall-mounted, surface metal raceway multi-outlet assemblies.
2. Wall-mounted, surface nonmetallic raceway multi-outlet assemblies.
3. Floor-mounted, recessed metal raceway multi-outlet assemblies.
4. Indoor service poles.
5. Floor-mounted, enclosure multi-outlet assemblies.
6. Fire-rated, poke-through assemblies.
7. Above-floor service fittings.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED, SURFACE METAL RACEWAY MULTI-OUTLET ASSEMBLIES – NOT USED

2.2 WALL-MOUNTED, SURFACE NONMETALLIC RACEWAY MULTI-OUTLET ASSEMBLIES – NOT USED

2.3 FLOOR-MOUNTED, RECESSED METAL RACEWAY MULTI-OUTLET ASSEMBLIES

A. Description: Two-piece flush-mounted, in-floor, metal raceway, with factory-wired multi-outlet harness, for installation flush in floor or under floor finish.

B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

C. General Characteristics:

1. Reference Standards: UL 5 for exposed power raceway and fittings, UL 5C for exposed communications raceway and fittings, and UL 2024 for communications cable routing.
2. Provide separate paths for management of telecommunications and power cables.

D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways and receptacles.

E. Floor-Mounted, Recessed Metal Raceway Power Multi-Outlet:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated; Wiring Device-Kellems.
   b. Wiremold (Legrand).
2. Options:
   a. Load-Bearing Capacity: 1000 lb (450 kg).
   b. Material: Steel with manufacturer's standard finish.
   c. Color: As indicated on the architectural drawings.
   d. Power Outlets: NEMA WD 6 Configuration 5-20R in accordance with Section 262726 "Wiring Devices" in surface-mounted enclosure capable of mounting anywhere along length of recessed raceway.
   e. Wiring: Single circuit in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Floor-Mounted, Recessed Metal Raceway Power and Communications Multi-Outlet Assembly:

1. Options:
   a. Load-Bearing Capacity: 1000 lb (450 kg).
   b. Material: Steel, with manufacturer's standard finish.
   c. Color: As indicated on the architectural drawings.
   d. Power Outlets: NEMA WD 6 Configuration 5-20R in accordance with Section 262726 "Wiring Devices" in surface-mounted enclosure capable of mounting anywhere along length of recessed raceway.
   e. Power Wiring: Single circuit in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

f. Voice and Data Communication Outlets: One blank insert with bushed cable opening complying with requirements in Section 271500 "Communications Horizontal Cabling."

g. A minimum of two four-pair cables in accordance with Section 271513 "Communications Copper Horizontal Cabling" for each outlet.

2.4 INDOOR SERVICE POLES – NOT USED

2.5 FLOOR-MOUNTED ENCLOSURE MULTI-OUTLET ASSEMBLIES – NOT USED

2.6 FIRE-RATED, POKE-THROUGH ASSEMBLIES – NOT USED

2.7 ABOVE-FLOOR SERVICE FITTINGS – NOT USED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1 for device mounting heights, except where requirements on Drawings or in this Section are stricter.

B. Comply with NECA 101 for installation requirements for steel raceways, except where requirements on Drawings or in this Section are stricter.

C. Comply with NECA 102 for installation requirements for aluminum raceways, except where requirements on Drawings or in this Section are stricter.

D. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies.

E. Provide terminations, adapters, boxes, and other fittings required for installation.

F. Install surface raceway with a minimum 2 inch (50 mm) radius control at bend points.

G. Secure metallic surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch (1200 mm) and with no fewer than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's instructions. Tape and glue are unacceptable support methods.

H. Do not install aluminum raceways or fittings in contact with concrete.

I. Secure nonmetallic surface raceway with screws or other anchor-type devices in each wiring channel at intervals not exceeding 18 inch (460 mm) and with no fewer than two supports per straight raceway section in each wiring channel. Support nonmetallic surface raceway in accordance with manufacturer's instructions. Tape and glue are unacceptable support methods.

J. Do not install PVC raceways where ambient temperature exceeds 122 deg F (50 deg C). Conductors with insulation rated higher than 75 deg C installed in PVC raceways may not be operated at a temperature greater than 75 deg C.

K. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."

L. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and support.

M. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" and Section 260533.23 "Surface Raceways for Electrical Systems" for installation of raceways.

N. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for additional requirements for floor boxes.

O. Coordination with Other Work:

1. Adjust locations of multi-outlet assemblies to suit arrangement of partitions and furnishings. Locate outlets to avoid blocking by supports, furnishings, and other architectural fixtures.
2. Provide outlets with special requirements, such as GFCI, AFCI, or special environmental requirements, where required by Drawings or to meet codes.
3. Adjust locations of poke-through assembly penetrations to coordinate with locations of structural members, concealed piping, and concealed conduit. Obtain written approval from Architect prior to drilling penetrations in floors other than where dimensioned on architectural Drawings. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 IDENTIFICATION

A. Comply with Section 260553 "Identification for Electrical Systems."

END OF SECTION 262719

SECTION 262726

WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches, dimmer switches, and fan-speed controller switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Hospital-grade straight-blade receptacles.
5. Receptacles with arc-fault and ground-fault protective devices.
6. Special-purpose power outlet assemblies.
7. Connectors, cords, and plugs.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies temperature, humidity, acoustical, and other field conditions applicable to the Work specified in this Section.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies seismic hazard, wind hazard, other structural load design conditions applicable to the Work specified in this Section.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional coordination, scheduling, sequencing, submittal, and installation requirements applicable to the Work for electrical, communications, and electronic safety and security systems on the Project, including wiring methods.
4. Section 260526 "Grounding and Bonding for Electrical Systems" specifies grounding and bonding referenced by this Section.
5. Section 260533.16 "Boxes and Covers for Electrical Systems" specifies covers and cover plates referenced by this Section.
6. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs referenced by this Section.
7. Section 260923 "Lighting Control Devices" for occupancy sensors, timers, control-voltage switches, and control-voltage dimmers.

1.2 DEFINITIONS

A. AFCI: Arc-Fault Circuit Interrupter.

B. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.

C. GFCI: Ground-Fault Circuit Interrupter.

D. UL 1472 Type I Dimmer: Dimmer in which air-gap switch is used to energize preset lighting levels.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.
   a. If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.
   b. Listing criteria identified in approval letter must match specified listing criteria. UL label indicating approval of equipment's enclosure is not considered approval of equipment for intended application.
   c. Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for discontinued or superseded products are not acceptable for submitted product.
2. Include manufacturer's sample extended warranty language.

B. Samples:

1. One for each kind of toggle switch and cover plate accessory specified, in each finish and color specified.
2. One for each kind of rocker switch and cover plate accessory specified, in each finish and color specified.
3. One for each kind of dimmer switch and cover plate accessory specified, in each finish and color specified.
4. One for each kind of single straight-blade receptacle and cover plate accessory specified, in each finish and color specified.
5. One for each kind of duplex straight-blade receptacle and cover plate accessory specified, in each finish and color specified.
6. One for each kind of duplex straight-blade receptacle with integral switching means and cover plate accessory specified, in each finish and color specified.
7. One for each kind of hospital-grade straight-blade receptacle and cover plate accessory specified, in each finish and color specified.
8. One for each kind of receptacle with GFCI device and cover plate accessory specified, in each finish and color specified.

9. One for each kind of cord connector specified, in each finish and color specified.

C. Shop Drawings:

1. Wiring diagrams for duplex straight-blade receptacles with integral switching means.

D. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer's published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.

1.6 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra stock material.

B. Special tools.

1.8 QUALIFICATIONS – NOT USED

1.9 WARRANTY FOR DEVICES – NOT USED

1.10 WARRANTY FOR CORD REELS – NOT USED

PART 2 - PRODUCTS

2.1 EXISTING PRODUCTS TO BE MODIFIED – NOT USED

2.2 EXISTING PRODUCTS TO BE REMOVED AND REINSTALLED - NOT USED

2.3 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.4 GENERAL-USE SWITCHES, DIMMER SWITCHES, AND FAN-SPEED CONTROLLER SWITCHES

A. Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).

b. Hubbell Incorporated; Wiring Device-Kellems.

c. Leviton Manufacturing Co., Inc.

d. Pass & Seymour/Legrand

2. Source Limitations: Obtain products from single manufacturer.

3. Listing Criteria: UL CCN WMUZ and UL 20.

4. Standard Features:

a. Device Color:
1) Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing and subject to final approval at shop drawing review.
2) Wiring Devices Connected to Emergency Electrical System: Red.
b. Configuration:
1) Extra-heavy-duty, 120-277 V, 20 A single pole, double pole, three way, and four way.

5. Accessories:
a. Cover Plate: Type 302 stainless steel; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Rocker Switch:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Eaton (Arrow Hart).
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: UL CCN WMUZ and UL 20.
4. Standard Features:
a. Device Color:
1) Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing and subject to final approval at shop drawing review.
2) Wiring Devices Connected to Essential Electrical System: Red.
b. Configuration:
1) 120-277 V, 20 A, single pole.
5. Accessories:
a. Cover Plate: Type 302 stainless steel gh; from same manufacturer as wiring device.
b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

A. Type I Dimmer Switch:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Lutron.
b. Hubbell Incorporated; Wiring Device-Kellems.
c. Leviton Manufacturing Co., Inc.
d. Pass & Seymour/Legrand

2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria: UL CCN EOYX and UL 1472.
4. Standard Features:
   a. UL 1472 Type I dimmer.
   b. Device Color: As indicated on architectural Drawing**s**.
   c. Switch Style: Toggle.
   d. Dimming Control Style: Slide.
5. Accessories:
   a. Type 302 stainless steel from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.5 GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES – NOT USED

2.6 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
   b. Surge Protective Devices: UL 1449, Type 3.
3. Standard Features:
   a. Device Color:
      1) Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing and subject to final approval at shop drawing review.
      2) Wiring Devices Connected to Essential Electrical System: Red.
      3) SPD Devices: Blue.

4) Isolated-Ground Receptacles: As specified above, with orange triangle on face.

b. Configuration:

1) Extra-heavy-duty, NEMA 5-15R, NEMA 5-20R.

2) Extra-heavy-duty, smooth face, NEMA 5-15R, NEMA 5-20R.

4. Other Available Features Required by the Project:

a. Has factory-terminated connectors on wiring device pigtails for quick installation.

5. Accessories:

a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.

b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Tamper-Resistant Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Eaton (Arrow Hart).

b. Hubbell Incorporated; Wiring Device-Kellems.

c. Leviton Manufacturing Co., Inc.

d. Pass & Seymour/Legrand

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:

a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.

b. Surge Protective Devices: UL 1449, Type 3.

3. Standard Features:

a. Device Color:

1) Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing and subject to final approval at shop drawing review.

2) Wiring Devices Connected to Essential Electrical System: Red.

3) SPD Devices: Blue.

4) Isolated-Ground Receptacles: As specified above, with orange triangle on face.

b. Configuration:

1) Extra-heavy-duty, NEMA 5-15R, NEMA 5-20R.

4. Other Available Features Required by the Project:
   a. Has factory-terminated connectors on wiring device pigtails for quick installation.
5. Accessories:
   a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
6. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand
7. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
   b. Surge Protective Devices: UL 1449, Type 3.
8. Standard Features:
   a. Device Color:
      1) Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing and subject to final approval at shop drawing review.
      2) Wiring Devices Connected to Essential Electrical System: Red.
      3) SPD Devices: Blue.
      4) Isolated-Ground Receptacles: As specified above, with orange triangle on face.
   b. Configuration:
      1) Extra-heavy-duty, NEMA 5-15R, NEMA 5-20R.
9. Other Available Features Required by the Project:
   a. Has factory-terminated connectors on wiring device pigtails for quick installation.
10. Accessories:
   a. Cover Plate: 0.060 inch (1.5 mm) thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.

b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.7 HOSPITAL-GRADE STRAIGHT-BLADE RECEPTACLES

A. Hospital-Grade, Non-Ferrous Duplex Straight-Blade (USED IN ALL PATIENT CARE SPACES):

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.
   d. Pass & Seymour/Legrand
2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
   b. Surge Protective Devices: UL 1449, Type 3.
3. Standard Features:
   a. Device Color:
      1) Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing and subject to final approval at shop drawing review.
      2) Wiring Devices Connected to Essential Electrical System: Red.
      3) SPD Devices: Blue.
      4) Isolated-Ground Receptacles: As specified above, with orange triangle on face.
   b. Configuration: Extra-heavy-duty, NEMAAA 5-20R.
4. Other Available Features Required by the Project:
   a. Has factory-terminated connectors on wiring device pigtails for quick installation.
5. Accessories:
   a. Cover Plate: Type 302 stainless steel; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Hospital-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Arrow Hart).
   b. Hubbell Incorporated; Wiring Device-Kellems.
   c. Leviton Manufacturing Co., Inc.

d. Pass & Seymour/Legrand

2. Listing Criteria: Investigated, labeled, and marked by qualified electrical testing laboratory in accordance with guide information and standards specified for the following UL product categories:
   a. Receptacles for Plugs and Attachment Plugs: UL CCN RTRT and UL 498.
   b. Surge Protective Devices: UL 1449, Type 3.
3. Standard Features:
   a. Device Color:
      1) Wiring Devices Connected to Normal Power System: Ivory unless otherwise indicated or required by NFPA 70 or device listing and subject to final approval at shop drawing review.
      2) Wiring Devices Connected to Essential Electrical System: Red.
   b. Configuration:
      1) Extra-heavy-duty, NEMA 5-20R.
      2) Extra-heavy-duty, smooth face, NEMA 5-20R.
4. Other Available Features Required by the Project:
   a. Has factory-terminated connectors on wiring device pigtails for quick installation.
5. Accessories:
   a. Cover Plate: Type 302 stainless steel; from same manufacturer as wiring device.
   b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.8 RECEPTACLES WITH ARC-FAULT AND GROUND-FAULT PROTECTIVE DEVICES – NOT USED

2.9 LOCKING RECEPTACLES – NOT USED

2.10 PIN-AND-SLEEVE RECEPTACLES – NOT USED

2.11 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES – NOT USED

2.12 CONNECTORS, CORDS, AND PLUGS – NOT USED

2.13 MAINTENANCE MATERIAL ITEMS FOR STRAIGHT-BLADE RECEPTACLES

A. Extra Stock Material: Furnish to Owner extra materials, from same production run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Include the following:
   1. SPD Receptacles: Equal to 10 percent of quantity installed for each kind specified, but no fewer than one units.

B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to controlled receptacles, that are packaged with protective covering for storage on-site and identified with labels describing contents.

2.14 MAINTENANCE MATERIAL ITEMS FOR CONNECTORS, CORDS, AND PLUGS – NOT USED

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

3.2 SELECTION OF CONTROLLED AND UNCONTROLLED RECEPTACLES – NOT USED

3.3 SELECTION OF GFCI RECEPTACLES

A. Healthcare Facilities: Unless protection of downstream branch-circuit wiring, cord sets, and power-supply cords is required by NFPA 70 or NFPA 99, provide non-feed-through GFCI receptacles.

3.4 INSTALLATION OF SWITCHES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Life Safety and Means of Egress Work: NFPA 101.
4. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
5. Wiring Devices: NECA NEIS 130.
6. Mounting Heights: NECA NEIS 1.
7. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Identification:
   a. Identify cover or cover plate for device with panelboard identification and circuit number.
   b. Mark cover or cover plate using hot, stamped, or engraved machine printing with black or red-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
   c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
   d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.5 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
4. Work in ITE Rooms: NFPA 75.
5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
6. Work in Confined Spaces: NFPA 350.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
    a. Hospital-Grade Receptacle Orientation: Orient receptacle with ground pin or neutral pin at top.
11. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Identification: Provide labels for receptacles and associated electrical equipment.
    a. Identify field-installed conductors, interconnecting wiring, and components.
    b. Label each enclosure with engraved metal or laminated-plastic nameplate.
        1) Identify cover or cover plate for device with panelboard identification and circuit number.
        2) Mark cover or cover plate using hot, stamped, or engraved machine printing with black or red-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
    c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
    d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

2. Do not install Type 3 SPD, including surge-protected relocatable taps and power strips, on branch circuit downstream of GFCI device.

3.6 INSTALLATION OF LOCKING RECEPTACLES

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Safety: NFPA 70E.
3. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
4. Work in ITE Rooms: NFPA 75.
5. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
6. Work in Confined Spaces: NFPA 350.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
8. Installing and Maintaining Wiring Devices: NECA NEIS 130.
9. Mounting Heights: Unless otherwise indicated in the Contract Documents, comply with mounting heights recommended in NECA NEIS 1.
10. Receptacle Orientation: Unless otherwise indicated in the Contract Documents, orient receptacle to match configuration diagram in NEMA WD 6.
11. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Identification: Provide labels for receptacles and associated electrical equipment.
   a. Identify field-installed conductors, interconnecting wiring, and components.
   b. Label each enclosure with engraved metal or laminated-plastic nameplate.
      1) Identify cover or cover plate for device with panelboard identification and circuit number.
      2) Mark cover or cover plate using hot, stamped, or engraved machine printing with black or red-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
   c. Provide warning signs and arc-flash hazard warning labels for electrical equipment.
   d. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.7 INSTALLATION OF PIN-AND-SLEEVE RECEPTACLES – NOT USED

3.8 INSTALLATION OF CORD REELS AND FITTINGS – NOT USED

3.9 INSTALLATION OF CONNECTORS, CORDS, AND PLUGS – NOT USED

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in the Contract Documents or manufacturer's published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Electrical Maintenance: NFPA 70B.
3. Electrical Safety: NFPA 70E.
4. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
5. Work in ITE Rooms: NFPA 75.
6. Work in Health Care Facilities: NFPA 99 and Article 517 of NFPA 70.
7. Work in Basements and Other Developed Subterranean Spaces: NFPA 520.
8. Consult Architect for resolution of conflicting requirements.

C. Interfaces with Other Work:

1. Coordinate with Section 262726.43 "Special-Purpose Power Outlet Assemblies" for installation of connectors and cords on fabricated power-outlet cord management assemblies.

3.10 FIELD QUALITY CONTROL OF SWITCHES

A. Tests and Inspections:

1. Perform tests and inspections in accordance with manufacturers' published instructions.

B. Nonconforming Work:

1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.11 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.

6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.

B. Nonconforming Work:
1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.12 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

A. Tests and Inspections:
1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' published instructions.

B. Nonconforming Work:
1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.13 FIELD QUALITY CONTROL OF PIN-AND-SLEEVE RECEPTACLES – NOT USED

3.14 FIELD QUALITY CONTROL OF CORD REELS AND FITTINGS – NOT USED

3.15 FIELD QUALITY CONTROL OF CONNECTORS, CORDS, AND PLUGS

A. Tests and Inspections:
1. Perform tests and inspections indicated in manufacturer's published instructions.

B. Nonconforming Work:
1. Unit will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

3.16 SYSTEM STARTUP FOR SWITCHES

A. Perform startup service.
1. Complete installation and startup checks in accordance with manufacturer's published instructions.

3.17 ADJUSTING

A. Occupancy Adjustments for Controlled Receptacles: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to the Project during other-than-normal occupancy hours for this purpose.

3.18 PROTECTION

A. Devices:

1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

B. Connectors, Cords, and Plugs:

1. After installation, protect connectors, cords, and plugs from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 262726

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SECTION 262816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case circuit breakers (MCCBs).
4. Enclosures.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. GFEP: Ground-fault circuit-interrupter for equipment protection.

B. GFLS: Ground-fault circuit-interrupter for life safety.

C. NC: Normally closed.

D. NO: Normally open.

E. SPDT: Single pole, double throw.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
2. Enclosure types and details for types other than UL 50E, Type 1.
3. Current and voltage ratings.
4. Short-circuit current ratings (interrupting and withstand, as appropriate).
5. Include evidence of qualified electrical testing laboratory listing for series rating of installed devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
7. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.
   1. Include plans, elevations, sections, details, and attachments to other work.
   2. Include wiring diagrams for power, signal, and control wiring.

C. Field Quality-Control Submittals:
   1. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
      a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts: Furnish to Owner spare parts, for repairing enclosed switches and circuit breakers, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:
   1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than six of each size and type.
   2. Fuse Pullers: Two for each size and type.

1.7 FIELD CONDITIONS:

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

2. Altitude: Not exceeding 6600 feet (2010 m).

1.8 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that enclosed switches and circuit breakers perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Three years from date of Substantial Completion; prorated coverage for labor, materials, and equipment.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Source Limitations: Obtain products from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

2.2 FUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company.
3. Siemens Industy, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty:

1. Single throw.
2. Three pole.
3. 240 and 600 V(ac).
4. 1200 A and smaller.

5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses.
6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Hookstick Handle: Allows use of hookstick to operate handle.
7. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120 V(ac).
8. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. General Electric Company.
3. Siemens Industy, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 240 and 600 V(ac), 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.

4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Service-Rated Switches: Labeled for use as service equipment.
6. Hookstick Handle: Allows use of hookstick to operate handle.
7. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 120 V(ac).
8. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.4 RECEPTACLE SWITCHES – NOT USED

2.5 SHUNT TRIP SWITCHES – NOT USED

2.6 MOLDED-CASE CIRCUIT BREAKERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
2. General Electric Company.
3. Siemens Industy, Inc., Energy Management Division.
4. Square D; by Schneider Electric.

B. Circuit breakers must be constructed using glass-reinforced insulating material. Current carrying components must be completely isolated from handle and accessory mounting area.

C. Circuit breakers must have toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. Circuit-breaker handle must be over center, be trip free, and reside in tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon must be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with push-to-trip button, located on face of circuit breaker to mechanically operate circuit-breaker tripping mechanism for maintenance and testing purposes.

D. Maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings must be clearly marked on face of circuit breaker. Circuit breakers must be 100 percent rated.

E. MCCBs must be equipped with a device for locking in isolated position.

F. Lugs must be suitable for 75 deg C (167 deg F) rated wire.

G. Standard: Comply with UL 489 with required interrupting capacity for available fault currents.

H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, RMS sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I-squared t response.

K. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.

M. GFLS Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6 mA trip).

N. GFEP Circuit Breakers: With Class B ground-fault protection (30 mA trip).

O. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
4. Lugs: Mechanical or Compression type, suitable for number, size, trip ratings, and conductor material.
5. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered or remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
8. Zone-Selective Interlocking: Integral with ground-fault trip unit; for interlocking ground-fault protection function.
9. Electrical Operator: Provide remote control for on, off, and reset operations.

10. Accessory Control Power: Integrally mounted, self-powered or Remote mounted and powered; 120 V(ac).

2.7 MOLDED-CASE SWITCHES – NOT USED

2.8 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, UL 50E, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: Enclosure must be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (UL 50E Type 1), gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (UL 50E Types 3R, 12).

C. Conduit Entry: UL 50E Types 4, 4X, and 12 enclosures may not contain knockouts. UL 50E Types 7 and 9 enclosures must be provided with threaded conduit openings in both end walls.

D. Operating Mechanism: Circuit-breaker operating handle must be externally operable with operating mechanism being integral part of box, not cover directly operable through front cover of enclosure (UL 50E Type 1), directly operable through dead front trim of enclosure (UL 50E Type 3R). Cover interlock mechanism must have externally operated override. Override may not permanently disable interlock mechanism, which must return to locked position once override is released. Tool used to override cover interlock mechanism must not be required to enter enclosure in order to override interlock.

E. Enclosures designated as UL 50E Type 4, 4X stainless steel, 12, or 12K must have dual cover interlock mechanism to prevent unintentional opening of enclosure cover when circuit breaker is ON and to prevent turning circuit breaker ON when enclosure cover is open.

F. UL 50E Type 7/9 enclosures must be furnished with breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

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

1. Commencement of work will indicate Installer's acceptance of areas and conditions as satisfactory.

3.2 SELECTION OF ENCLOSURES

A. Indoor, Dry and Clean Locations: UL 50E, Type 1.

B. Outdoor Locations: UL 50E, Type 3R.

3.3 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Special Techniques:

1. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in fusible devices.
6. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.5 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Perform tests and inspections reports.

B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:
   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, grounding, and clearances.
   c. Verify that unit is clean.
   d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
   e. Verify that fuse sizes and types match the Specifications and Drawings.
   f. Verify that each fuse has adequate mechanical support and contact integrity.
   g. Inspect bolted electrical connections for high resistance using one of the following methods:
      1) Use low-resistance ohmmeter.
         a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on Drawings.

i. Verify correct phase barrier installation.

j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.

b. Measure contact resistance across each switchblade fuseholder. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.

c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

e. Perform ground fault test in accordance with NETA ATS Section 7.14 "Ground Fault Protection Systems, Low-Voltage."

D. Tests and Inspections for Molded-Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on Drawings.

b. Inspect physical and mechanical condition.

c. Inspect anchorage, alignment, grounding, and clearances.

d. Verify that unit is clean.

e. Operate circuit breaker to ensure smooth operation.

f. Inspect bolted electrical connections for high resistance using one of the following methods:

1) Use low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels must be in accordance with manufacturer's published data. In absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.

h. Perform adjustments for final protective device settings in accordance with coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.

b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, use Table 100.1 from NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

c. Perform contact/pole resistance test. Drop values may not exceed high level of manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of lowest value.

d. Perform insulation resistance tests on control wiring with respect to ground. Applied potential must be 500 V (dc) for 300 V rated cable and 1000 V (dc) for 600 V rated cable. Test duration must be one minute. For units with solid state components,

follow manufacturer's recommendation. Insulation resistance values may be no less than 2 M Ω.

e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

2) Short-time pickup and delay. Short-time pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

3) Ground-fault pickup and time delay. Ground-fault pickup values must be as specified. Trip characteristics may not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.

4) Instantaneous pickup. Instantaneous pickup values must be as specified and within manufacturer's published tolerances.

f. Test functionality of trip unit by means of primary current injection. Pickup values and trip characteristics must be as specified and within manufacturer's published tolerances.

g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of shunt trip and close coils must be as indicated by manufacturer.

h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset trip logs and indicators. Investigate units that do not function as designed.

i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Test and adjust controls, remote monitoring, and safeties.

E. Nonconforming Work:

1. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

2. Remove and replace defective units and retest.

F. Collect, assemble, and submit test and inspection reports.

1. Test procedures used.

2. Include identification of each enclosed switch and circuit breaker tested and describe test results.

3. List deficiencies detected, remedial action taken, and observations after remedial action.

G. Manufacturer Services:

1. Engage factory-authorized service representative to supervise field tests and inspections.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges to values as coordinated with the engineer of record.

3.7 PROTECTION

A. After installation, protect enclosed switches and circuit breakers from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.8 MAINTENANCE

A. Infrared Scanning of Enclosed Switches and Breakers: Two months after Substantial Completion, perform infrared scan of joints and connections. Remove covers so joints and connections are accessible to portable scanner. Take visible light photographs at same locations and orientations as infrared scans for documentation to ensure follow-on scans match same conditions for valid comparison.

1. Instruments and Equipment: Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Follow-up Infrared Scanning: Perform two follow-up infrared scans of enclosed switches and breakers, one at four months and another at 11 months after Substantial Completion.
3. Instrument: Use infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide documentation of device calibration.
4. Report: Prepare certified report that identifies units checked and that describes scanning results. Include notation of deficiencies detected, remedial actions taken, and scanning observations after remedial action.

END OF SECTION 262816

SECTION 262923

VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

A. CPT: Control power transformer.

B. DDC: Direct digital control.

C. EMI: Electromagnetic interference.

D. LED: Light-emitting diode.

E. NC: Normally closed.

F. NO: Normally open.

G. OCPD: Overcurrent protective device.

H. PID: Control action, proportional plus integral plus derivative.

I. RFI: Radio-frequency interference.

J. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

1. Include dimensions and finishes for VFCs.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.

2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.

3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Data: Certificates, for each VFC, accessories, and components, from manufacturer.
1. Certificate of compliance.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

D. Product Certificates: For each VFC from manufacturer.

E. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
b. Manufacturer's written instructions for setting field-adjustable overload relays.
c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.7 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.9 WARRANTY

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

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

PART 2 - PRODUCTS

2.1 VARIABLE-FREQUENCY MOTOR CONTROLLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Eaton.
2. Rockwell; Allen Bradley.
3. Siemens
4. Square D; by Schneider Electric.

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 61800-5-1.

B. Application: Constant torque and variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 5 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 95 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 95 percent under any load or speed condition.
6. Minimum Short-Circuit Current (Withstand) Rating: 65 kA.
7. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet (1000 m).

10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.

I. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: UL 489, instantaneous-trip circuit breaker with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
4. Unless noted otherwise, equip each VFC with not less than two NC and two NO alarm contacts that operate only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.

6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
    a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:
    a. A minimum of two programmable analog inputs: 0- to 10-V dc, 4- to 20-mA dc.
    b. A minimum of six multifunction programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
    a. 0- to 10-V dc.

b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
a. Motor running.
b. Set point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
1. Number of Loops: One.

G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
1. Hardwired Points:
a. Monitoring: On-off status.
b. Control: On-off operation.
2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.5 LINE CONDITIONING AND FILTERING

A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total

harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.

B. EMI/RFI Filtering:

1. CE marked; certify compliance with IEC 61800-3 for Category C2.

2.6 BYPASS SYSTEMS

A. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode:

1. Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.
2. Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic-control system feedback.

C. Bypass Controller:

1. Two-Contactor-Style Bypass: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
   a. Bypass Contactor: Load-break, NEMA-rated contactor.
   b. Output Isolating Contactor: Non-load-break, NEMA-rated contactor.
   c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
2. Three-Contactor-Style Bypass: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.
   a. Bypass Contactor: Load-break, NEMA-rated contactor.
   b. Input and Output Isolating Contactors: Non-load-break, NEMA-rated contactors.

c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

D. Bypass Contactor Configuration: Full-voltage (across-the-line) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
   a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
   b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with control power source of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
   a. CPT Spare Capacity: 200 VA.
6. Overload Relays: NEMA ICS 2.
   a. Melting-Alloy Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   b. Bimetallic Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      4) Ambient compensated.
      5) Automatic resetting.
   c. Solid-State Overload Relays:
      1) Switch or dial selectable for motor-running overload protection.
      2) Sensors in each phase.

3) Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

5) Analog communication module.

d. NC isolated overload alarm contact.

e. External overload, reset push button.

2.7 OPTIONAL FEATURES

A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications when overload protection activates.

1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
2. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
3. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

B. Damper control circuit with end-of-travel feedback capability.

C. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.

D. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.

E. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from smoke-control fan controller, this password-protected input:

1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
3. Forces VFC to transfer to bypass mode and operate motor at full speed.
4. Causes display of override mode on the VFC display.
5. Reset VFC to normal operation on removal of override signal automatically.

F. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

G. Remote digital operator kit.

H. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.8 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
   1. Dry and Clean Indoor Locations: Type 1.
   2. Outdoor Locations: Type 3R.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.9 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
   1. Push Buttons: Lockable.
   2. Pilot Lights: Push to test.
   3. Selector Switches: Rotary type.
   4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

B. NC bypass contactor auxiliary contact(s).

C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
   1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:
   1. Elapsed-time meter.
   2. Kilowatt meter.
   3. Kilowatt-hour meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

H. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with stainless steel intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

I. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.

J. Spare control-wiring terminal blocks; unwired.

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work

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

3.2 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting Controllers: Install VFCs on 4-inch (100-mm) nominal thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."

D. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in each fusible-switch VFC.

G. Install fuses in control circuits if not factory installed

H. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

I. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

J. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control devices where applicable.
1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

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

C. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.

c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

E. VFCs will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges to values as coordinated with the engineer of record.

F. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

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SECTION 263213.13

DIESEL-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Diesel-engine-driven generator sets.
2. Diesel engine.
3. Diesel fuel-oil system.
4. Control and monitoring.
5. Generator overcurrent and fault protection.
6. Generator, exciter, and voltage regulator.
7. Outdoor engine generator enclosure.
8. Vibration isolation devices.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in gallons per hour (liters per hour) at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include airflow requirements for cooling and combustion air in cubic feet per minute (cubic meters per minute) at 0.8 power factor, with air-supply temperature of 95, 80, 70, and

50 deg F (35, 27, 21, and 10 deg C). Provide Drawings indicating requirements and limitations for location of air intake and exhausts.

7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer and testing agency.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: With engine and generator mounted on rails, identify center of gravity and total weight**,** including full fuel tank, supplied enclosure, external silencer, subbase-mounted fuel tank, skid-mounted load bank, and each piece of equipment not integral to the engine generator, and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.

3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
   b. Operating instructions laminated and mounted adjacent to generator location.
   c. Training plan.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 DIESEL-ENGINE-DRIVEN GENERATOR SETS

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Caterpillar, Inc.; Electric Power Division.
2. Cummins Power Generation.

B. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, subbase fuel tank**,** engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: 1.5.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level [**1**] [**2**] EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier **2** requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 104 deg F (Minus 15 to plus 40 deg C).
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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

C. Power Rating: Standby.

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. EPSS Class: Engine generator shall be classified as a Class 96 according to NFPA 110.

F. Service Load: See Plans.

G. Power Factor: 0.8, lagging.

H. Frequency: 60 Hz.

I. Voltage: 480-V ac.

J. Phase: Three-phase, four wire, wye.

K. Induction Method: Turbocharged.

L. Governor: Adjustable isochronous, with speed sensing.

M. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

N. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.

2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

O. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time:
   a. Comply with NFPA 110, Type 10 system requirements.
   b. 10 seconds.

P. Engine Generator Performance for Sensitive Loads:
1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
   a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
    a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time:
    a. Comply with NFPA 110, Type 10 system requirements.
    b. 10 seconds.

Q. Parallel Engine Generators:
1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.
B. Rated Engine Speed: 1800 rpm.
C. Lubrication System: Engine or skid-mounted.
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499 and with NFPA 110 requirements for Level 1 equipment for heater capacity.

E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.
    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer:

1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
    a. Minimum sound attenuation of 25 dB at 500 Hz.
    b. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F (minus 40 to plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 37.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Fuel-Oil Storage Tank:

1. Fuel Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills plus fuel for the hours of continuous Large subbase tanks can raise the generator, making maintenance access difficult; subbase tanks are also of limited capacity, making them generally unsuitable for prime power applications. Design for access platform or other methods of maintenance access. Coordinate platform with room size, seismic qualification, stair requirements, height restrictions, and structural capacity. Note that handrails may be required depending on height above finished floor. Handrails may need to be removable for some maintenance activities.

G. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:

1. Tank level indicator.
2. Fuel-Tank Capacity: Minimum 133 percent of total fuel required for planned operation plus fuel for periodic maintenance operations between fuel refills.
3. Leak detection in interstitial space.
4. Vandal-resistant fill cap.
5. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run time control set for **15** minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration:

1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.
2. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
3. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:
    a. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.

F. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.
    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, connected to a phase selector switch.

f. AC ammeter, connected to a phase selector switch.

g. AC frequency meter.

h. Generator-voltage adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:

a. Cranking control equipment.

b. Run-Off-Auto switch.

c. Control switch not in automatic position alarm.

d. Overcrank alarm.

e. Overcrank shutdown device.

f. Low-water temperature alarm.

g. High engine temperature prealarm.

h. High engine temperature.

i. High engine temperature shutdown device.

j. Overspeed alarm.

k. Overspeed shutdown device.

l. Low fuel main tank.

1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for duration required for the indicated EPSS class.

m. Coolant low-level alarm.

n. Coolant low-level shutdown device.

o. Coolant high-temperature prealarm.

p. Coolant high-temperature alarm.

q. Coolant low-temperature alarm.

r. Coolant high-temperature shutdown device.

s. EPS load indicator.

t. Battery high-voltage alarm.

u. Low cranking voltage alarm.

v. Battery-charger malfunction alarm.

w. Battery low-voltage alarm.

x. Lamp test.

y. Contacts for local and remote common alarm.

z. Low-starting air pressure alarm.

aa. Low-starting hydraulic pressure alarm.

bb. Remote manual stop shutdown device.

cc. Air shutdown damper alarm when used.

dd. Air shutdown damper shutdown device when used.

ee. Generator overcurrent-protective-device not-closed alarm.

G. Connection to Datalink:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via Ethernet.

H. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

I. Remote Alarm Annunciator: An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Low water-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low fuel main tank alarm.
8. Low coolant level alarm.
9. Low cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.

19. Generator overcurrent-protective-device not-closed alarm.

J. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

K. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:

1. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
   a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
   b. Trip Settings: Selected to coordinate with generator thermal damage curve.
   c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
   d. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.

3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

D. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.
1. Indicate ground fault with other engine generator alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.
B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
C. Electrical Insulation: Class H or Class F.
D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six-lead alternator.
E. Range: Provide limited range of output voltage by adjusting the excitation level.
F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
G. Enclosure: Dripproof.
H. Instrument Transformers: Mounted within generator enclosure.
I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.
1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 20 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 10 percent and stabilize at rated frequency within 2 seconds.
J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
L. Subtransient Reactance: 12 percent, maximum.

2.9 LOAD BANK – NOT USED

2.10 OUTDOOR ENGINE GENERATOR ENCLOSURE

A. Description:

1. Vandal-resistant, sound-attenuating, weatherproof steel housing; wind resistant up to 130 mph (209 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
   a. Sound Attenuation Level: 78 dBA.
2. Prefabricated or pre-engineered, galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure; erected on concrete foundation.

B. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 130 mph (209 km/h).

C. Hinged Doors: With padlocking provisions.

D. Space Heater: Thermostatically controlled and sized to prevent condensation.

E. Lighting: Provide weather-resistant LED lighting with 50 fc (550 lx) average maintained.

F. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.

G. Muffler Location: Within enclosure.

H. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
1. Louvers: Fixed-engine, cooling-air inlet and discharge. Stormproof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

I. Interior Lights with Switch: Factory-wired, vapor-proof luminaires within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.

J. Convenience Outlets: Factory-wired, GFCI. Arrange for external electrical connection.

K. Provide a 208/120-volt, single phase, load center in the generator enclosure rated minimum 60 amps and with 12 spaces for providing circuits for lights, engine jacket heater, receptacle, and other necessary generator accessories requiring power. The accessories shall be wired by the Contractor or generator manufacturer and included fully in the Contract.

2.11 REMOTE RADIATOR MOTORS – NOT USED

2.12 VIBRATION ISOLATION DEVICES

A. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
   2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Minimum Deflection: 1 inch (25 mm).
B. Comply with requirements for vibration isolation and flexible connector materials for steel piping.
C. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.
D. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.13 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.14 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
   1. Tests: Comply with IEEE 115 and with NFPA 110, Level 1 Energy Converters.
B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
   1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
   2. Test generator, exciter, and voltage regulator as a unit.
   3. Full load run.
   4. Maximum power.
   5. Voltage regulation.
   6. Transient and steady-state governing.

7. Single-step load pickup.
8. Safety shutdown.
9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
10. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

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

3.2 PREPARATION – NOT USED

3.3 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure enclosure to anchor bolts installed in concrete bases.

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."

2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) of clearance from combustibles.

F. Drain Piping: Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

G. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect engine exhaust pipe to engine with flexible connector.

C. Connect fuel piping to engines with a gate valve and union and flexible connector.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

F. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency:

1. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
2. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.
   a. Visual and Mechanical Inspection:
      1) Compare equipment nameplate data with Drawings and the Specifications.
      2) Inspect physical and mechanical condition.
      3) Inspect anchorage, alignment, and grounding.
      4) Verify that the unit is clean.
   b. Electrical and Mechanical Tests:
      1) Perform insulation-resistance tests according to IEEE 43.
         a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
         b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
      2) Test protective relay devices.
      3) Verify phase rotation, phasing, and synchronized operation as required by the application.
      4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
      5) Perform vibration test for each main bearing cap.
      6) Verify correct functioning of the governor and regulator.
      7) Conduct performance test according to NFPA 110.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
   a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer's specifications.
4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Exhaust Emissions Test: Comply with applicable government test criteria.
8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (8 m) from edge of the generator enclosure, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection

while running with maximum load. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's authorized service representative. Include quarterly preventive maintenance and exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Parts shall be manufacturer's authorized replacement parts and supplies.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.13

SECTION 263600

TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Contactor-type automatic transfer switches.
2. Transfer switch accessories.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Contactor-type automatic transfer switches. Circuit breaker type not allowed.
2. Transfer switch accessories.

B. Product Data Submittals: For each product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

C. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Features and operating sequences, both automatic and manual.

b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.5 QUALITY ASSURANCE – NOT USED

1.6 FIELD CONDITIONS – NOT USED

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

B. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.

2. Short-time withstand capability for three cycles.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Neutral Switching: Provide overlapping neutral contacts.

L. Neutral Terminal: Not used.

M. Battery Charger: For generator starting batteries.

1. Float type, rated 10 A.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

N. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

O. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via front access.

P. Enclosures: General-purpose NEMA 250, Type 3R, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Caterpillar, Inc.; Electric Power Division.
2. Cummins Power Generation.
3. Emerson.
4. Russ Electric, Inc.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.

1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
    a. Initiation occurs without active control of generator.
    b. Automatic transfer-switch controller takes active control of generator to match frequency, phase angle, and voltage.
    c. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
4. Failure of power source serving load initiates automatic break-before-make transfer.

E. Manual Switch Operation, Load-Breaking: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

F. Manual Switch Operation, Non-Load-Breaking: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

G. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

H. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

I. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

J. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.

11. Engine Shutdown Contacts:
    a. Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
    b. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

K. Large-Motor-Load Power Transfer:
1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.3 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES – NOT USED

2.4 NONAUTOMATIC TRANSFER SWITCHES – NOT USED

2.5 TRANSFER SWITCH ACCESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
   a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
   b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
   c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
   d. Transition:
      1) Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
      2) Provide **closed**-transition operation when transferring between power sources.
   e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
   f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
   g. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
   h. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
   i. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.

j. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.

4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency systems. Include results of test for the following conditions:

a. Overvoltage.
b. Undervoltage.
c. Loss of supply voltage.
d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
4. Provide workspace and clearances required by NFPA 70.

B. Identify components according to Section 260553 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways specified in Section 260533.13 "Conduits for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

G. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

H. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.3 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:

1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
2. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Tests and Inspections:

1. After installing equipment, test for compliance with requirements according to NETA ATS.

2. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and required clearances.
   d. Verify that the unit is clean.
   e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   f. Verify that manual transfer warnings are attached and visible.
   g. Verify tightness of all control connections.
   h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
   i. Perform manual transfer operation.
   j. Verify positive mechanical interlocking between normal and alternate sources.
   k. Perform visual and mechanical inspection of surge arresters.
   l. Inspect control power transformers.
      1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
      2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
      3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.
3. Electrical Tests:
   a. Perform insulation-resistance tests on all control wiring with respect to ground.
   b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
   c. Verify settings and operation of control devices.
   d. Calibrate and set all relays and timers.
   e. Verify phase rotation, phasing, and synchronized operation.
   f. Perform automatic transfer tests.
   g. Verify correct operation and timing of the following functions:
      1) Normal source voltage-sensing and frequency-sensing relays.
      2) Engine start sequence.

3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.
5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
   a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
   g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
   a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Transfer switches will be considered defective if they do not pass tests and inspections.

F. Remove and replace malfunctioning units and retest as specified above.

G. Prepare test and inspection reports.

H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 263600

SECTION 264113

LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Lightning protection system for ordinary structures.

B. Section Includes: Lightning protection system for the following:

1. Ordinary structures.

1.2 ACTION SUBMITTALS

A. Product Data: For each product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Include roof attachment details, coordinated with roof installation.
5. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lightning protection cabling attachments to roofing systems and accessories.
2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

B. Qualification Data: For Installer.

C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For lightning protection system to include in maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."

b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

B. Completion Certificate:

1. UL Master Label Certificate.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY or LPI Master Installer.

PART 2 - PRODUCTS

2.1 LIGHTNING PROTECTION FOR STRUCTURES

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

1. Harger Lightning & Grounding.
2. Heary Bros. Lightning Protection Co. Inc.
3. Robbins Lightning, Inc.
4. Thompson Lightning Protection, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.

C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:

1. Copper unless otherwise indicated.
2. 3/8-inch (10-mm) diameter by minimum 15 inches (380 mm) long.
3. Pointed tip.
4. Threaded base support.

B. Air Terminal Bracing:

1. Copper.
2. 1/4-inch (6-mm) diameter rod.

C. Class I Main Conductors:

1. Stranded Copper: 57,400 circular mils in diameter.

D. Secondary Conductors:

1. Stranded Copper: 26,240 circular mils in diameter.

E. Ground Loop Conductor: Stranded copper.

F. Ground Rods:

1. Material: Copper-clad steel.
2. Diameter: 5/8 inch (16 mm).
3. Rods shall be not less than 120 inches (3050 mm) long.

G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in UL 96A.

1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
2. Install conduit where necessary to comply with conductor concealment requirements.
3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: high compression.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.
2. Perform inspections to obtain an LPI certification.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

SECTION 264313

SURGE PROTECTIVE DEVICES FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type 1 surge protective devices (SPDs).
2. Type 2 surge protective devices (SPDs).
3. Type 3, Type 4, and Type 5 surge protective devices (SPDs).
4. Enclosures.
5. Conductors and cables.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
2. Section 262416 "Panelboards" for integral SPDs installed by panelboard manufacturer.
3. Section 262726 "Wiring Devices" for integral SPDs installed by receptacle manufacturer.

1.2 DEFINITIONS

A. I_n: Nominal discharge current.

B. Maximum Continuous Operating Voltage (MCOV): The maximum designated RMS value of the power frequency voltage that may be continuously applied to the mode of protection of an SPD.

C. Metal-Oxide Varistor (MOV): An electronic component with a significant bidirectional, nonlinear current-voltage characteristic.

D. Mode(s), Modes of Protection, or Protection Modes: Electrical paths where the SPD offers defense against transient over voltages. Examples include: line to neutral (L-N), line to ground (L-G), line to line (L-L), and neutral to ground (N-G).

E. SCCR: Short-circuit current rating.

F. Type 1 SPDs: Permanently connected SPDs intended for installation between the secondary of the service transformer and the line side of the service disconnect overcurrent device.

G. Voltage Protection Rating (VPR): A rating selected from UL 1449 list of preferred values assigned to each mode of protection.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
   a. Include electrical characteristics, specialties, and accessories for SPDs.

b. Certification of compliance with UL 1449 by qualified electrical testing laboratory recognized by authorities having jurisdiction including the following information:
   1) Tested values for VPRs.
   2) I_n ratings.
   3) MCOV, type designations.
   4) OCPD requirements.
   5) Manufacturer's model number.
   6) System voltage.
   7) Modes of protection.

B. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance Data: For SPDs to include in maintenance manuals.

1.6 WARRANTY

A. Special Manufacturer Extended Warranty: Manufacturer warrants that SPDs perform in accordance with specified requirements and agrees to provide repair or replacement of SPDs that fail to perform as specified within extended warranty period.
   1. Initial Extended Warranty Period: Five year(s) from date of Substantial Completion, for labor, materials, and equipment.
   2. Follow-On Extended Warranty Period: 10 year(s) from date of Substantial Completion, for materials only, f.o.b. the nearest shipping point to Project site.

PART 2 - PRODUCTS

2.1 TYPE 1 SURGE PROTECTIVE DEVICES (SPDs)

A. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
   1. Advanced Protection Technologies Inc. (APT)
   2. Current Technology Inc.
   3. Schneider Electric USA, Inc.

B. Source Limitations: Obtain devices from single source from single manufacturer.

C. General Characteristics:
   1. Reference Standards: UL 1449, Type 1.
   2. MCOV: Not less than 125 percent of nominal system voltage for 208Y/120 V and 120/240 V power systems, and not less than 115 percent of nominal system voltage for 480Y/277 V power systems.

3. Peak Surge Current Rating: Minimum single-pulse surge current withstand rating per phase must not be less than 320 kA. Peak surge current rating must be arithmetic sum of the ratings of individual MOVs in a given mode.
4. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V, three-phase, four-wire circuits must not exceed the following:
   a. Line to Neutral: 1200 V for 480Y/277 V.
   b. Line to Line: 2000 V for 480Y/277 V.
5. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits must not exceed the following:
   a. Line to Neutral: 700 V.
   b. Line to Line: 1200 V.
6. SCCR: Equal or exceed 200 kA.
7. I_n Rating: 20 kA.

D. Options:
1. Include integral disconnect switch.
2. Include internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include indicator light display for protection status.
4. Include audible alarm.
5. Include NEMA ICS 5, dry Form C contacts rated at 2 A and 24 V(ac) for remote monitoring of protection status.
6. Include surge counter.

2.2 TYPE 2 SURGE PROTECTIVE DEVICES (SPDs) – NOT USED

2.3 TYPE 3, TYPE 4, AND TYPE 5 SURGE PROTECTIVE DEVICES (SPDs) – NOT USED

2.4 ENCLOSURES

A. Indoor Enclosures: Type 1.

2.5 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide OCPD and disconnect for installation of SPD in accordance with UL 1449 and manufacturer's instructions.

B. Install leads between disconnects and SPDs short, straight, twisted, and in accordance with manufacturer's instructions. Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
   1. Do not splice and extend SPD leads unless specifically permitted by manufacturer.
   2. Do not exceed manufacturer's recommended lead length.
   3. Do not bond neutral and ground.

C. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by authorities having jurisdiction.

B. Tests and Inspections:
   1. Compare equipment nameplate data for compliance with Drawings and the Specifications.
   2. Inspect anchorage, alignment, grounding, and clearances.
   3. Verify that electrical wiring installation complies with manufacturer's installation requirements.

C. Nonconforming Work:
   1. SPDs that do not pass tests and inspections will be considered defective.
   2. Remove and replace defective units and retest.

D. Prepare test and inspection reports.

E. Manufacturer Services:
   1. Engage factory-authorized service representative to supervise field tests and inspections.

3.3 STARTUP SERVICE

A. Complete startup checks in accordance with manufacturer's instructions.

B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests; reconnect them immediately after the testing is over.

C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

A. Train Owner’s maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

SECTION 265000

LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Luminaires.
2. Luminaire fittings.

B. Related Requirements:

1. Section 018116 "Facility Environmental Requirements" specifies basis-of-design environmental conditions and performance criteria that are applicable to product selection and installation of the Work on the Project.
2. Section 018123 "Facility Seismic and Wind Criteria" specifies basis-of-design seismic and wind criteria for nonstructural components on the Project.
3. Section 260010 "Supplemental Requirements for Electrical" specifies additional requirements applicable to coordinating, scheduling, and sequencing of the Work specified in this Section.
4. Section 260519 "Low-Voltage Electrical Power Conductors and Cables specifies wiring connections installed by this Section.
5. Section 260529 "Hangers and Supports for Electrical Systems" specifies channel and angle supports installed by this Section.
6. Section 260546 "Poles for Electrical Systems" specifies lighting standards, utility poles, and accessories referenced by this Section.
7. Section 260553 "Identification for Electrical Systems" specifies electrical equipment labels and warning signs installed by this Section.
8. Section 260923 "Lighting Control Devices" specifies automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors installed by this Section.

1.2 DEFINITIONS

A. BUG Rating: Backlight, uplight, and glare rating for light pollution from exterior luminaires.

B. Correlated Color Temperature (CCT): The absolute temperature (in kelvins) of a blackbody whose chromaticity (color quality) most nearly resembles that of the light source.

C. Color Rendering Index (CRI): The measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference light source. The lower the CRI of a light source, the more difficult it is to identify colors and stripes on electronic components and wiring.

D. IDA: International Dark-Sky Association.

E. IES: Illuminating Engineering Society.

F. LPD: Lighting power density.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Luminaires: Include the following additional information:

a. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.

1) If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.

2) Listing criteria identified in approval letter must match specified listing criteria. Approval of only equipment's enclosure is not considered approval of equipment for intended application.

3) Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for similar products are not acceptable.

b. Product Certificates: Include product certificates stating compliance with standards listed below, signed by manufacturer or fabricator.

1) Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with current accreditation under National Voluntary Laboratory Accreditation Program (NVLAP) for Energy Efficient Lighting Products.

2) Testing Agency Certified Data: For luminaires indicated on Lighting Fixture Schedule on the Drawings, photometric data certified by qualified independent testing laboratory. Photometric data for remaining luminaires must be certified by manufacturer.

c. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

d. Include operating characteristics, electrical characteristics, and furnished accessories.

e. Include schedule of submitted lighting products. Arrange schedule and accompanying product data in order by luminaire and lamp designations indicated on the Drawings.

f. Include battery and charger data for emergency lighting units.

g. Include ballast factor.

h. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.

i. Include photometric data and adjustment factors obtained from qualified laboratory tests.

j. Include manufacturer's sample warranty language.

2. Luminaire Fittings: Include the following additional information:

a. Product Listing: Include copy of unexpired approval letter, on letterhead of qualified electrical testing agency, certifying product's compliance with specified listing criteria.

1) If listed manufacturer differs from selling manufacturer, indicate relationship between entities on submittal. Clearly indicate which entity warrants product performance and fitness for purpose.

2) Listing criteria identified in approval letter must match specified listing criteria. Approval of only equipment's enclosure is not considered approval of equipment for intended application.

3) Product identification in approval letter must match product branding and model numbers in submittal. Approval letters for similar products are not acceptable.

b. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

c. Include operating characteristics, electrical characteristics, and furnished accessories.

d. Include schedule of submitted lighting products. Arrange schedule and accompanying product data in order by luminaire and lamp designations indicated on the Drawings.

e. Include manufacturer's sample warranty language.

B. Samples:

1. Luminaires: One for each kind of luminaire with specified rating, size, finish, color, and texture.

2. Luminaire Fittings: One for each kind of luminaire fitting with specified rating, size, finish, color, and texture.

C. Shop Drawings: Prepare and submit the following:

1. Drawings, Diagrams, and Supporting Documents for Custom Luminaires:

a. Include plans, elevations, sections, and mounting and attachment details.

b. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

D. Field quality-control reports.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturers' published instructions.

B. Field Reports:

1. Manufacturer's field reports for field quality-control support.
2. Manufacturer's field reports for system startup support.

1.5 CLOSEOUT SUBMITTALS

A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Spare parts.

B. Extra stock material.

1.7 MOCKUPS

A. Provide mockups as indicated on the Drawings to verify selections made under Sample submittals and to set quality standards for materials and execution.

1. Build mockup of luminaires in room or space, complete with power and control connections.
2. Obtain Architect's approval of mockups before starting installation of related Work on the Project.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
4. Maintain mockups during construction in undisturbed condition as standard for judging the completed Work.
5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 QUALIFICATIONS – NOT USED

1.9 DELIVERY, STORAGE, AND HANDLING

A. Protect exposed surface finishes on lighting equipment by applying strippable, temporary protective covering before shipping.

1.10 WARRANTY FOR LUMINAIRES

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed luminaires perform in accordance with specified requirements and agrees to repair or replace products that fail to perform as specified within extended-warranty period. Warranty must convey to Owner upon acceptance of the Work.

1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that luminaires perform in accordance with specified requirements and agrees to provide repair or replacement of products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Five years from date of Substantial Completion; full coverage for labor, materials, and equipment.

1.11 WARRANTY FOR BATTERIES

A. Special Manufacturer Extended Warranty for Batteries: Manufacturer warrants that batteries perform in accordance with specified requirements and agrees to provide repair or replacement of batteries that fail to perform as specified within extended-warranty period.

1. Initial Extended-Warranty Period for Li-ion Batteries: Three years from date of Substantial Completion; full coverage for materials only, free on board origin, freight prepaid.
2. Follow-On Extended-Warranty Period for Li-ion Batteries: 10 years from date of Substantial Completion; prorated coverage for materials only, free on board origin, freight prepaid.
3. Initial Extended-Warranty Period for Ni-Cd Batteries: Five years from date of Substantial Completion; full coverage for materials only, free on board origin, freight prepaid.
4. Follow-On Extended-Warranty Period for Ni-Cd Batteries: 15 years from date of Substantial Completion; prorated coverage for materials only, free on board origin, freight prepaid.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Products or components listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

C. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified.

D. Ambient Temperature: 5 to 104 deg F (Minus 15 to plus 40 deg C).

1. Relative Humidity: Zero to 95 percent.

E. Altitude: Sea level to 1000 feet (300 m).

2.2 LUMINAIRES

A. Recessed Luminaire: This product type covers luminaires intended for installation in recessed cavities in walls, ceilings, and similar locations where thermal insulation may be installed in accordance with Parts XI and XII in Article 410 of NFPA 70.

1. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper Lighting, an Eaton business.
   b. Finelite.
   c. H.E. Williams.
   d. Lithonia Lighting; Acuity Brands Lighting, Inc.
2. Source Limitations: Obtain products for this luminaire type from single manufacturer.
3. Listing Criteria:
   a. LED Luminaires: UL CCN IFAO; including UL 1598.
   b. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
4. Luminaire Description: See lighting fixture schedule.
5. Standard Features:
   a. Ceiling Compatibility: NEMA LE 4.
   b. Openings: Doors, frames, and access panels must operate smoothly, not leak light under operating conditions, and permit relamping without the use of tools or parts falling from enclosure.
   c. Nominal Operating Voltage: Universal.
   d. CRI: 80**+**.
   e. Ballast or Driver Location: Internal.
   f. Materials:
      1) Enclosure: ASTM B209/B209M extruded-aluminum ASTM A568/A568M sheet steel housing and heat sink; free of sharp edges and burrs.
      2) Enclosure Ingress Protection Rating: UL 50E Type 1 or IEC 60529 IP20 or UL 50E Type 3R or IEC 60529 IP24.
      3) Lenses, Diffusers, and Globes:
         a) Fixed lens.
         b) As scheduled light distribution.
         c) Annealed crystal glass unless otherwise indicated.
         d) Lens Thickness: Not less than 0.125 inch (3 mm) unless otherwise indicated.

4) Visible variations in metal finishes outside range of approved Samples are unacceptable in adjoining components.

g. LED Luminaires (UL CCN IFAO):

1) Output Intensity: Minimum as scheduled on plans.

2) Efficacy: Not less than 85 lm/W.

3) Rated Life: 50,000 hours to L70.

4) CCT: 4000 K.

6. Other Available Features Required by the Project:

a. Mounting Hardware: Ceiling-mounted; include universal mounting bracket and integral junction box with conduit fittings.

b. Finishes:

1) Enclosure: Clear anodized finish.

2) Reflector: Aluminum.

3) Visible variations in metal finishes outside range of approved Samples are unacceptable in adjoining components.

c. Dimmable from 100 percent to zero percent of maximum light output.

d. EMI Filters: Factory installed to suppress conducted EMI in accordance with MIL-STD-461E. Fabricate luminaires with one filter on each ballast or driver requiring filter.

e. Stainless steel latches.

f. Integral pressure equalizer.

7. Installation Markings:

a. Relamping Labels: Include recommended lamp type, diameter, shape, size, wattage, and coating on factory-applied label that is visible when luminaire is open for relamping.

b. All Luminaires (UL CCN HYXT):

1) “USE ONLY” and include specific lamp type.

2) Lamp diameter, shape, size, wattage, and coating.

3) CCT and CRI

B. UL FWBO - Exit Fixture:

1. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

a. Cooper Lighting, an Eaton business.

b. Finelite.

c. H.E. Williams.

d. Lithonia Lighting; Acuity Brands Lighting, Inc.

2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria:
   a. Exit Fixtures: UL CCN FWBO; including UL 924, NFPA 101, and ICC IBC.
   b. Marked in accordance with UL CCN HYXT, including UL 1598, for compatible power supply, installation location, and environmental conditions.
4. Product Description: See lighting fixture schedule.
5. Standard Features:
   a. Nominal Operating Voltage: Universal.
   b. Light Source: LED; 50,000 hours minimum rated life.
   c. Legend Color: Red.
   d. Internal emergency power unit.
   e. Master/Remote Sign Configurations:
      1) Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply for power connection to remote unit.
      2) Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.
6. Installation Markings:
   a. All Luminaires (UL CCN HYXT):
      1) "SUITABLE FOR DAMP LOCATIONS."
      2) Marked to identify voltage supply or type of branch circuit or both.
   b. Exit Fixtures (UL CCN FWBO):
      1) "SUITABLE FOR OPERATION IN AMBIENTS NOT EXCEEDING 40℃."

C. DOWNLIGHT
1. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
   a. Cooper Lighting, an Eaton business.
   b. Juno Lighting Group.
   c. Lightolier; a Signify group brand.
   d. Lithonia Lighting; Acuity Brands Lighting, Inc.
2. Nominal Operating Voltage: Universal
3. Lamp:
   a. Minimum See Fixture Schedule.

b. Minimum allowable efficacy of 80 lm/W.
c. CRI of 80. CCT of 4000K.
d. Rated lamp life of 35,000 hours to L70.
e. Dimmable from 100 percent to 0 percent of maximum light output.
f. Internal driver.
g. User-Replaceable Lamps Modules
h. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

4. Housings:
a. Extruded-aluminum or Steel housing and heat sink.
b. Finish as specified in schedule.
c. Universal mounting bracket.
d. Integral junction box with conduit fittings.

5. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

6. Diffusers and Globes:
a. Fixed or Adjustable lens a scheduled.
b. Medium light distribution unless otherwise scheduled.
c. Materials as scheduled.
d. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
e. Glass: Annealed crystal glass unless otherwise indicated.
f. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

7. Standards:
a. ENERGY STAR certified.
b. RoHS compliant.
c. UL Listing: Listed for damp location.
d. Recessed luminaires shall comply with NEMA LE 4.

D. STRIP LIGHT

1. Manufacturer: Subject to compliance with requirements, provide products by one of the following:
a. Cooper Lighting, an Eaton business.

b. Lithonia Lighting; Acuity Brands Lighting, Inc.
c. Signify Lighting Company.

2. Nominal Operating Voltage: Universal
3. Lamp:
   a. Minimum See Fixture Schedule.
   b. Minimum allowable efficacy of 75 lm/W.
   c. CRI of 70. CCT of 4000K.
   d. Rated lamp life of 50,000 hours to L70.
   e. Dimmable from 100 percent to 0 percent of maximum light output.
   f. Internal driver.
   g. User-Replaceable Lamps Modules
   h. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.
4. Housings:
   a. Extruded-aluminum or Steel housing and heat sink.
   b. Finish as specified in schedule.
   c. With integral mounting provisions
5. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
6. Diffusers and Globes:
   a. Materials as scheduled.
   b. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   c. Glass: Annealed crystal glass unless otherwise indicated.
   d. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.
7. Standards:
   a. ENERGY STAR certified.
   b. RoHS compliant.
   c. UL Listing: Listed for damp location.

E. SUSPENDED, NONLINEAR

1. Manufacturer: Subject to compliance with requirements, provide products by one of the following:

a. Cooper Lighting, an Eaton business.
b. Finelite
c. Lithonia Lighting; Acuity Brands Lighting, Inc.
d. Prudential.

2. Nominal Operating Voltage: Universal
3. Lamp:
   a. Minimum Lumens as scheduled.
   b. Minimum allowable efficacy of 85 lm/W.
   c. CRI of 80. CCT of 4000K.
   d. Rated lamp life of 50,000 hours to L70.
   e. Dimmable from 100 percent to 0 percent of maximum light output.
   f. Internal driver.
   g. User-Replaceable Lamps Modules
   h. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.
4. Housings:
   a. Extruded-aluminum or Steel housing and heat sink.
   b. Finish as specified in schedule.
   c. Universal mounting bracket.
   d. Integral junction box with conduit fittings.
5. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
6. Diffusers and Globes:
   a. Materials as scheduled.
   b. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   c. Glass: Annealed crystal glass unless otherwise indicated.
   d. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.
7. Standards:
   a. ENERGY STAR certified.
   b. RoHS compliant.
   c. UL Listing: Listed for damp location.

2.3 LUMINAIRE FITTINGS

A. Luminaire Support Accessories:

1. Standard Features:

a. Sized and rated for luminaire weight.

b. Capable of maintaining luminaire position after cleaning and relamping.

c. Capable of supporting luminaire without causing deflection of ceiling or wall.

d. Capable of supporting horizontal force equal to 100 percent of luminaire weight and vertical force equal to 400 percent of luminaire weight.

2. Other Available Features Required by the Project:

a. Hook Hangers: Integrated assembly matched to luminaire, supply voltage, and equipment with threaded attachment, cord, and locking-type plug.

b. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm) wire supports adjustable to 10 ft (3 m) in length.

c. Aircraft Cables: 5/32 inch (4 mm) diameter aircraft cable supports 10 ft (3 m) in length.

d. Single-Stem Hangers: 1/2 inch (13 mm) nominal diameter steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

e. Rod Hangers: 3/16 inch (5 mm) nominal diameter, cadmium-plated, threaded steel rod.

2.4 MATERIALS

A. Metal parts:

1. Free of burrs and sharp corners and edges.

2. Sheet metal components shall be steel unless otherwise indicated.

3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A 36/A 36M for carbon structural steel.

2. ASTM A 568/A 568M for sheet steel.

C. Stainless steel:

1. Manufacturer's standard grade.

2. Manufacturer's standard type, ASTM A 240/240 M.

D. Galvanized Steel: ASTM A 653/A 653M.

E. Aluminum: ASTM B 209.

2.5 MAINTENANCE MATERIAL ITEMS

A. Spare Parts: Furnish to Owner spare parts, for repairing lighting equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents. Include the following:

1. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

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

3.2 PREPARATION

A. Temporary Lighting: If approved by Architect, specified luminaires for the Project may be installed for temporary lighting. Install and energize minimum quantity of luminaires necessary to meet needs of construction activities. When construction is sufficiently complete, remove, disassemble, clean, and relamp luminaires used for temporary lighting before reinstalling for the Project's delivery.

3.3 SELECTION OF LUMINAIRES – NOT USED

3.4 INSTALLATION OF LIGHTING

A. Comply with manufacturer's published instructions.

B. Reference Standards for Installation: Unless more stringent installation requirements are specified in Contract Documents or manufacturers' published instructions, comply with the following:

1. Electrical Construction: ICC IBC, ICC IFC, NFPA 1, NFPA 70, and NECA NEIS 1.
2. Grounding and Bonding: NECA NEIS 331 and Article 250 of NFPA 70.
3. Work in Confined Spaces: NFPA 350.
4. Installation of Indoor Lighting Systems: NECA NEIS 500.
5. Installation of Exterior Lighting Systems: NECA NEIS 501.
6. Installation of Luminaires, Lampholders, and Lamps: Article 410 of NFPA 70.
7. Installation of Lighting for Sensitive Electronic Equipment: Article 647 of NFPA 70.

8. Installation of Emergency Lighting and Exit Signs: ICC IBC, NFPA 101, and Parts IV and V in Article 700 of NFPA 70.
9. Consult Architect for resolution of conflicting requirements.

C. Special Installation Techniques:

1. Install luminaires level, plumb, and square with finished floor or grade unless otherwise indicated.
2. Install luminaires at height and aiming angle as indicated on the Drawings.
3. Coordinate layout and installation of luminaires with other construction.
4. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.
5. Exterior Corrosion Prevention:
   a. Do not use aluminum in contact with earth or concrete. When in direct contact with dissimilar metals, protect aluminum with insulating fittings or treatment.
   b. When embedding steel conduits in concrete, wrap conduit with 10 mil (0.254 mm) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
6. Flush-Mounted Luminaire Support:
   a. Secured to outlet box.
   b. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
   c. Trim ring flush with finished surface.
7. Wall-Mounted Luminaire Support: Attached to structural members in walls, attached to a minimum 20 gauge backing plate attached to wall structural members, or attached using through bolts and backing plates on either side of wall.
   a. Do not attach luminaires directly to gypsum board.
8. Suspended Luminaire Support:
   a. Ceiling Mount:
      1) Hook hangers.
      2) Two wires.
      3) Two 5/32-inch (4-mm) diameter aircraft cable supports adjustable to 10 feet (3 m) in length.
      4) Pendant mount with 5/32-inch (4-mm) diameter aircraft cable supports adjustable to 10 feet (3 m) in length.
   b. Pendants and Rods: Where longer than 48 inch (1220 mm), brace to limit swinging.

c. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.

d. Continuous Rows of Luminaires: Provide tubing or stem for wiring at one point, tubing or rod, or wire support for suspension for each unit length of luminaire chassis, including one at each end.

e. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

9. Ceiling-Grid-Mounted Luminaire Support:

a. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inch (150 mm) from luminaire corners.

b. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for application.

c. Luminaires of Sizes Smaller than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with no fewer than two 3/4 inch (20 mm) metal channels spanning and secured to ceiling tees.

d. Seismic Restraint: Install at least one independent support rod or wire from structure to tab on luminaire. Wire or rod must have breaking strength for luminaire weight with safety factor of 3.0.

10. Remote Mounting of Ballasts or Drivers: Do not exceed distance between ballast or driver and luminaire recommended by ballast or driver manufacturer.

11. Emergency Power Units: Secure with approved fasteners in four or more locations, spaced near corners of unit.

12. Install wiring connections for luminaires.

13. Identification: Provide labels for luminaires and associated electrical equipment.

a. Identify field-installed conductors, interconnecting wiring, and components.

b. Provide warning signs.

c. Label each enclosure with engraved metal or laminated-plastic nameplate.

D. Systems Integration: Integrate lighting control devices and equipment with electrical power connections for operation of luminaires as specified.

3.5 FIELD QUALITY CONTROL OF LIGHTING

A. Administrant for Electrical Power Tests and Inspections:

1. Owner will engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified electrical testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Administrant for Field Tests and Inspections of Lighting Installations:
1. Owner will engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified lighting testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Acceptance Testing Preparation:
1. Prepare test and inspection reports.

D. Field tests and inspections must be witnessed by authorities having jurisdiction.

E. Tests and Inspections:
1. Perform manufacturer's recommended tests and inspections.
2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
3. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
4. Verify operation of photoelectric controls.
5. Exterior Illumination Tests:
   a. Measure light intensities at night. Use photometers with calibration referenced to NIST standards.

F. Nonconforming Work:
1. Luminaire will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

G. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

H. Manufacturer Services: Engage factory-authorized service representative to supervise field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project's site.

3.6 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.
2. Burn-in lamps that require specific aging period to operate properly, prior to occupancy by Owner.

B. Manufacturer Services: Engage factory-authorized service representative to supervise system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at the Project's site.

3.7 ADJUSTING

A. Luminaire Aiming Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aiming direction of luminaires to suit occupied conditions. Make up to two visits to the Project's site during other-than-normal hours for this purpose. Some of the Work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies must be manufacturer's authorized replacement parts and supplies.
3. Adjust aim of luminaires in presence of Architect.

3.8 CLOSEOUT ACTIVITIES

A. Training:

1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:
   a. How to adjust, operate, and maintain luminaires and photoelectric controls.
2. Allow Owner to record training sessions.

3.9 PROTECTION

A. After installation, protect lighting equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 265000

SECTION 284621.11

ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Magnetic door holders.
8. Remote annunciator.
9. Addressable interface device.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

F. VESDA: Very Early Smoke-Detection Apparatus.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes,

indicate termination locations and requirements, and distinguish between factory and field wiring.

4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
    d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    e. Locate detectors according to manufacturer's written recommendations.
11. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:
1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level IV minimum.
    c. Licensed or certified by authorities having jurisdiction.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 Sample Warranty: For special warranty – NOT USED

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
   b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
   c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
   d. Riser diagram.
   e. Device addresses.
   f. Record copy of site-specific software.
   g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
      1) Equipment tested.
      2) Frequency of testing of installed components.
      3) Frequency of inspection of installed components.
      4) Requirements and recommendations related to results of maintenance.
      5) Manufacturer's user training manuals.
   h. Manufacturer's required maintenance related to system warranty requirements.
   i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.

3. Device address list.
4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Lamps for Remote Indicating Lamp Units: Quantity equal to 6 percent of amount installed, but no fewer than one unit.
   2. Lamps for Strobe Units: Quantity equal to 5 percent of amount installed, but no fewer than one unit.
   3. Smoke Detectors,: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
   4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than three unit of each type.
   5. Keys and Tools: One extra set for access to locked or tamper proofed components.
   6. Audible and Visual Notification Appliances: Three of each type installed.
   7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

C. NFPA Certification: Obtain certification according to NFPA 72 by agency recognized by authority having jurisdiction.

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
   1. Notify Engineer no fewer than **seven** (7) days in advance of proposed interruption of fire-alarm service.
   2. Do not proceed with interruption of fire-alarm service without written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING – NOT USED

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

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

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Dry-Pipe automatic sprinkler low air pressure
7. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate alarm communication system.

7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
9. Recall elevators to primary or alternate recall floors.
10. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe sprinkler system. Elevator shunt-trip supervision.
3. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:
1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unitand remote annunciators.
3. Transmit system status to building management system.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. JCI/SimplexGrinnell LP

2.5 PREACTION SYSTEM – NOT USED

2.6 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.7 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
   a. Multiple levels of detection sensitivity for each sensor.

B. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.

d. Present sensitivity selected.

e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

a. Primary status.

b. Device type.

c. Present average value.

d. Present sensitivity selected.

e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.

4. Each sensor shall have multiple levels of detection sensitivity.

5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.8 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

1. Mounting: Adapter plate for outlet box mounting

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.9 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

B. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Rated Light Output:
   a. Labeled on Plans in cd.
   b. 15/30/75/110 cd, selectable in the field.
2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, white.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.11 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 ADDRESSABLE INTERFACE DEVICE

A. General:
   1. Include address-setting means on the module.
   2. Store an internal identifying code for control panel use to identify the module type.
   3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
   1. Allow the control panel to switch the relay contacts on command.
   2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:
   1. Operate notification devices.

2.13 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

C. Provide integration gateway using BACnet for connection to building automation system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
   1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the supervising station.
3. Expand, modify, and supplement existing equipment as necessary to extend existing functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

D. Manual Fire-Alarm Boxes:
1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing:
1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet (9 m).
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches (910 mm) from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

F. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

H. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, that is not readily visible from normal viewing position.

I. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.3 PATHWAYS

A. Pathways shall be installed in EMT.

B. All EMT shall be painted red enamel.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Supervisory connections at valve supervisory switches.
6. Supervisory connections at elevator shunt-trip breaker.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in this section."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect and authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

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

1. Visual Inspection: Conduct visual inspection prior to testing.
   a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
   b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 284621.11