

PROJECT MANUAL- VOL 2

PINE BUSH CENTRAL SCHOOL DISTRICT

PINE BUSH 2025 CIP PHASE 2

1953 State Route 302, Circleville, NY 10919

Pine Bush, New York 12566

VOL 2: Divions 15-48

CPL PROJECT NO.:R25.17714.01

DOCUMENT DATE: July 8, 2026

NY ENGINEERING FIRM CERTIFICATE # 0021419

NEW YORK STATE EDUCATION DEPARTMENT CONTROL NUMBER(S):

Circleville Elementary School	44-04-01-06-0-009-018
Circleville Middle School	44-04-01-06-0-014-019
Pakanasink Elementary School	44-04-01-06-0-012-019
Pine Bush High School	44-04-01-06-0-007-032

ALTERATION WARNING STATEMENT

It is a violation of the New York State Education Law and the Commissioner's regulations for any person, unless acting under the direction of a licensed Architect, Engineer or Land Surveyor, to alter an item in any way. If an item bearing the seal of an Architect, Engineer or Land Surveyor is altered, the altering party shall affix to the item, their seal and the notation "ALTERED BY", followed by their signature and the date of such alteration, and a specific description of the alteration.

DESIGN PROFESSIONAL'S CERTIFICATION

The undersigned certifies that, to the best of his or her knowledge, information and belief, that the "Design conforms to all applicable provisions of the current New York State Uniform Fire Prevention Code, Building Code and Energy Conservation Code, the building standards of the New York State Education Department and that the "Work will involve known or suspected ACBM, and will be done in accordance with Industrial Code Rule #56".

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**SECTION 220500
COMMON WORK RESULTS FOR PLUMBING**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Transition fittings.
 - 3. Mechanical sleeve seals.
 - 4. Sleeves.
 - 5. Escutcheons.
 - 6. Grout.
 - 7. Equipment installation requirements common to equipment sections, including electrical disconnects.
 - 8. Painting and finishing.
 - 9. Supports and anchorages.

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. Provide: To supply, furnish, install and connect, ready for safe and regular operation of the system or equipment.
- G. Install: To erect, mount and connect complete, with related accessories.
- H. Supply, Furnish: To purchase, procure, acquire and deliver complete, with related accessories.
- I. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. CPVC: Chlorinated polyvinyl chloride plastic.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.
- J. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

- A. Product Data: For the following:
 1. Transition fittings.
 2. Mechanical sleeve seals.
 3. Escutcheons.
- B. Welding certificates.

1.05 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.07 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate all plumbing piping and equipment with all other trades, including HVAC, electrical, structural and Architectural ceiling elevations.

PART 1 PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.03 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 - 2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining Plastic Piping:
 - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.04 TRANSITION FITTINGS

- A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Co.
 - b. Dresser Industries, Inc.; DMD Div.
 - c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
 - d. JCM Industries.
 - e. Smith-Blair, Inc.
 - f. Viking Johnson.
 - 2. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.
 - 3. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.
 - 4. Aboveground Pressure Piping: Pipe fitting.
- B. Plastic-to-Metal Transition Fittings: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
 - 1. Manufacturers:
 - a. Eslon Thermoplastics.

- C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
 - 1. Manufacturers:
 - a. Thompson Plastics, Inc.
- D. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Co.
 - b. Fernco, Inc.
 - c. Mission Rubber Company.
 - d. Plastic Oddities, Inc.

2.05 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.06 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.
- E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe: ASTM D 1785, Schedule 40.
- G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.07 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.
- E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.08 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 1 EXECUTION

3.01 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. 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 Coordination Drawings.
- C. Install piping in concealed locations, 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.
- 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. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

- b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type with spring clips.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
 - g. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw or spring clips.
 - h. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
 - i. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Permanent sleeves are not required for holes formed by removable PE sleeves.
- O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- 1. 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. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - 3. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
 - 4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- Q. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- 1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
 - 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- R. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
 2. Equal to Link-Seal by Garlock.
- S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- T. Verify final equipment locations for roughing-in.
- U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.02 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. 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 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.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic 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. PVC Nonpressure Piping: Join according to ASTM D 2855.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.03 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.04 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.
- E. Provide required electrical disconnects for all equipment, sized and rated for each associated piece of equipment. Coordinate with electrical contract for power connection.

3.05 PAINTING

- A. Painting of plumbing systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.06 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.07 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.08 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.

- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 220500

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**SECTION 220517
SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

- A. Pipe sleeves.
- B. Stack-Sleeve fittings.
- C. Sleeve-Seal Fittings
- D. Grout

1.03 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 099123 - Interior Painting: Preparation and painting of interior piping systems.
- C. Section 220523 - General-Duty Valves for Plumbing Piping.
- D. Section 220553 - Identification for Plumbing Piping and Equipment: Piping identification.
- E. Section 220719 - Plumbing Piping Insulation.

1.04 REFERENCE STANDARDS

- A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2016.
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2013a (Reapproved 2017).

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified this section.
 - 1. Minimum three years experience.
 - 2. Approved by manufacturer.
- C. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

1.08 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.01 PIPE SLEEVES

- A. Manufacturers:
 - 1. Flexicraft Industries; Pipe Wall Sleeve: www.flexicraft.com/#sle.
 - 2. Smith, Jay R. Mfg. Co..
 - 3. Zurn Specification Drainage Operation; Zurn Plumbing Products Group..
 - 4. Presealed Systems.
 - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.
- C. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.Pipe
- D. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- E. Passing Through Below Grade Exterior Walls:
 - 1. Zinc coated or cast iron pipe.
 - 2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
 - 3. Provide product equal to Link-Seal by Garlock.
- F. Clearances:
 - 1. Provide allowance for insulated piping.
 - 2. Wall, Floor, Partitions, and Beam Flanges: 1 inch greater than external pipe diameter.
 - 3. All Rated Openings: Caulked tight with fire stopping material complying with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.

2.02 STACK-SLEEVE FITTINGS

- A. Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping rings with setscrews.

2.03 SLEEVE-SEAL SYSTEMS

- A. Manufactured plastic, sleeve-type, water stop assemblies made for imbedding in concrete slab or wall. Unit has plastic or rubber water stop collar with center opening to match piping OD.

2.04 GROUT

- A. Standard: ASTM C 1107/C1107M Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Non shrink; recommended for interior and exterior applications.

- C. Design Mix: 5000-psi, 28 day compressive strength.
- D. Packaging: Premix and factory packaged.

PART 3 EXECUTION**3.01 PREPARATION**

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
- E. Manufactured Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Provide core through foundation wall sized as required by manufacturer of sleeve-seal system.
 - 4. Locate piping in center of sleeve or penetration.
 - 5. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
 - 6. Tighten bolting for a water-tight seal.
 - 7. Install in accordance with manufacturer's recommendations.
- F. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.03 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.
- C. See Section 017419 - Construction Waste Management and Disposal for additional requirements.

END OF SECTION 220517

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**SECTION 220523
GENERAL-DUTY VALVES FOR PLUMBING PIPING**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

- A. Ball valves.
- B. Butterfly valves.
- C. Check valves.
- D. Lubricated plug valves.

1.03 RELATED REQUIREMENTS

- A. Section 220553 - Identification for Plumbing Piping and Equipment.
- B. Section 220719 - Plumbing Piping Insulation.
- C. Section 221005 - Plumbing Piping.

1.04 ABBREVIATIONS AND ACRONYMS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Non-rising stem.
- E. OS&Y: Outside screw and yoke.
- F. PTFE: Polytetrafluoroethylene.
- G. RS: Rising stem.

1.05 REFERENCE STANDARDS

- A. ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).
- B. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves; 2017.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- D. ASME B31.9 - Building Services Piping; 2025.
- E. ASTM A48/A48M - Standard Specification for Gray Iron Castings; 2022.
- F. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2023).
- G. ASTM A536 - Standard Specification for Ductile Iron Castings; 2024.
- H. ASTM B61 - Standard Specification for Steam or Valve Bronze Castings; 2015 (Reapproved 2021).
- I. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings; 2017 (Reapproved 2025).
- J. AWWA C606 - Grooved and Shouldered Joints; 2022.

- K. MSS SP-67 - Butterfly Valves; 2017, with Errata.
- L. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends; 2018.
- M. MSS SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Service; 2010a.
- N. MSS SP-78 - Gray Iron Plug Valves, Flanged and Threaded Ends; 2011.
- O. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves; 2019.
- P. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .
- Q. NSF 61 - Drinking Water System Components - Health Effects; 2025, with Addendum
- R. NSF 372 - Drinking Water System Components - Lead Content; 2024.

1.06 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.07 QUALITY ASSURANCE

- A. Manufacturer:
 - 1. Obtain valves for each valve type from single manufacturer.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
 - 2. Protect valve parts exposed to piped medium against rust and corrosion.
 - 3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
 - 4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.
 - 5. Secure check valves in either the closed position or open position.
 - 6. Adjust butterfly valves to closed or partially closed position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection and protect flanges and specialties from dirt.
 - a. Provide temporary inlet and outlet caps.
 - b. Maintain caps in place until installation.
 - 2. Store valves in shipping containers and maintain in place until installation.
 - a. Store valves indoors in dry environment.
 - b. Store valves off the ground in watertight enclosures when indoor storage is not an option.

1.09 EXERCISE THE FOLLOWING PRECAUTIONS FOR HANDLING:

- A. Handle large valves with sling, modified to avoid damage to exposed parts.
- B. Avoid the use of operating handles or stems as rigging or lifting points.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- 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. Conbraco Industries Inc.; Apollo Valves.
2. Crane Co.; Crane Valve Group; Crane Valves.
3. Hammond Valve
4. Milwaukee Valve Company
5. NIBCO INC.
6. Red-White Valve Corporation
7. Watts Regulator Co.; a division of Watts Water Technologies. Inc.

2.02 APPLICATIONS

- A. Listed pipe sizes shown using nominal pipe sizes (NPS) and nominal diameter (DN).
- B. Provide the following valves for the applications if not indicated on drawings:
 1. Shutoff: Ball, butterfly, gate.
 2. Dead-End: Single-flange butterfly (lug) type.
 3. Throttling: Provide angle, ball, or butterfly.
 4. Swing Check (Pump Outlet):
 - a. 2 inch and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
 - b. 2-1/2 inch and Larger for Domestic Water: Iron swing check valves with closure control, metal or resilient seat check valves.
- C. Substitutions of valves with higher CWP classes or WSP ratings for same valve types are permitted when specified CWP ratings or WSP classes are not available.
- D. Required Valve End Connections for Non-Wafer Types:
 1. Steel Pipe:
 - a. 2 inch and Smaller: Threaded ends.
 - b. 2-1/2 inch to 4 inch: Grooved or flanged ends except where threaded valve-end option is indicated in valve schedules below.
 2. Copper Tube:
 - a. 2 inch and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - b. 2-1/2 inch to 4 inch: Grooved or flanged ends except where threaded valve-end option is indicated in valve schedules below.
- E. Domestic, Hot and Cold Water Valves:
 1. 2 inch and Smaller:
 - a. Ball: Two piece, full port, brass with brass trim.
 - b. Bronze Swing Check: Class 125, bronze disc.
 2. 2-1/2 inch and Larger:
 - a. Iron Grooved-End Butterfly: 175 CWP.
 - b. Iron Swing Check: Class 125, metal seats.

2.03 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- B. Valve Sizes: Match upstream piping unless otherwise indicated.
- C. Valve Actuator Types:
- D. Insulated Piping Valves: With 2 inch stem extensions and the following features:
 1. Gate Valves: Rising stem.

2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
- E. Valve-End Connections:
 1. Threaded End Valves: ASME B1.20.1.
 2. Solder Joint Connections: ASME B16.18.
 3. Grooved End Connections: AWWA C606.
- F. General ASME Compliance:
 1. Solder-joint Connections: ASME B16.18.
 2. Building Services Piping Valves: ASME B31.9.
- G. Potable Water Use:
 1. Certified: Approved for use in compliance with NSF 61 and NSF 372.
 2. Lead-Free Certified: Wetted surface material includes less than 0.25 percent lead content.
- H. Source Limitations: Obtain each valve type from a single manufacturer.

2.04 BRONZE, BALL VALVES

- A. General:
 1. Fabricate from dezincification resistant material.
 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. Two Piece, Full Port with Stainless Steel Trim:
 1. Comply with MSS SP-110.
 2. WSP Rating: 150 psi.
 3. WOG Rating: 600 psi.
 4. Body: Forged bronze or dezincified-brass alloy.
 5. Ends Connections: Pipe thread or solder.
 6. Seats: PTFE.
 7. Stem: Stainless steel, blowout proof.
 8. Ball: Stainless steel, vented.
 9. Manufacturers:
 - a. Apollo Valves; _____: www.apollovalves.com/#sle.
 - b. Watts
 - c. Nibco - Equal to 585HP-66-LF

2.05 IRON, SINGLE FLANGE BUTTERFLY VALVES

- A. Wafer Style:
 1. Class 125, or Class 150 flanges.
 2. Comply with MSS SP-67, Type I.
 3. Lug Style, Service Pressure Ratings:
 - a. 150 psi for sizes 14 to 24 inch.
 - b. 250 psi for sizes 2 to 12 inch.
 - c. Vacuum down to 29.9 in-Hg.
 4. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 5. Stem: One or two-piece stainless steel.
 6. Seat: EPDM.
 7. Disc: Aluminum-bronze.

8. Finish: Epoxy coated.
9. Operator: Gear operator with handwheel over direct-mount actuator base.

2.06 IRON, GROOVED-END BUTTERFLY VALVES

- A. CWP Rating: 175 psi.
 1. Comply with MSS SP-67, Type I.
 2. Body: Coated ductile iron.
 3. Stem: Two-piece stainless steel.
 4. Disc: Coated ductile iron.
 5. Disc Seal: EPDM.

2.07 BRONZE, LIFT CHECK VALVES

- A. General:
 1. Fabricate from dezincification resistant material.
 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. Class 125:
 1. Comply with MSS SP-80, Type 1, Metal Disc to Metal Seat and Type 2, Nonmetallic Disc to Metal Seat.
 2. CWP Rating: 200 psi.
 3. Design: Vertical flow.
 4. Body: Comply with ASTM B61 or ASTM B62, bronze.
 5. End Connections: Threaded.
 6. Disc (Type 1): Bronze.

2.08 BRASS, HORIZONTAL SWING CHECK VALVES

- A. Class 125, Threaded or Soldered End Connections:
 1. WOG Rating: 200 psi.
 2. Body: Forged brass.
 3. Disc: Forged brass.
 4. Hinge-Pin, Screw, and Cap: Forged brass.

2.09 BRONZE, SWING CHECK VALVES

- A. General:
 1. Fabricate from dezincification resistant material.
 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. Class 125:
 1. Pressure and Temperature Rating: MSS SP-80, Type 3.
 2. Design: Y-pattern, horizontal or vertical flow.
 3. WOG Rating: 200 psi.
 4. Body: Bronze, ASTM B62.
 5. End Connections: Threaded.
 6. Disc: Bronze.

2.10 IRON, SWING CHECK VALVES WITH CLOSURE CONTROL

- A. Class 125 with Lever and Spring-Closure Control.
 1. Comply with MSS SP-71, Type I.
 2. Description:
 - a. CWP Rating: 200 psi.

- b. Design: Clear or full waterway.
- c. Body: ASTM A126, gray iron with bolted bonnet.
- d. Ends: Flanged as indicated.
- e. Trim: Bronze.
- f. Gasket: Asbestos free.
- g. Closer Control: Factory installed, exterior lever, and weight.

2.11 LUBRICATED PLUG VALVES

- A. Regular Gland with Flanged Ends:
 - 1. Comply with MSS SP-78, Type II.
 - 2. Body: ASTM A48/A48M or ASTM A126, cast iron with lubrication sealing system.
 - 3. Pattern: Regular or short.
 - 4. Plug: Cast iron or bronze with sealant groove.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Discard all packing materials and verify that valve interior, including threads and flanges are completely clean without signs of damage or degradation that could result in leakage.
- B. Verify valve parts to be fully operational in all positions from closed to fully open.
- C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.
- D. Should valve is determined to be defective, replace with new valve.

3.02 INSTALLATION

- A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.
- B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.
- C. Where valve support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- D. Install check valves where necessary to maintain direction of flow as follows:
 - 1. Lift Check: Install with stem plumb and vertical.
 - 2. Swing Check: Install horizontal maintaining hinge pin level.
 - 3. Orient plate-type into horizontal or vertical position, between flanges.

END OF SECTION 220523

**SECTION 220529
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

- A. Beam clamps.
- B. Pipe hangers.
- C. Pipe supports, guides, shields, and saddles.
- D. Anchors and fasteners.

1.03 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 055000 - Metal Fabrications.

1.04 REFERENCE STANDARDS

- A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.
- B. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2022).
- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2024.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2016a.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping; 2023.
- D. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates; 2024.
- E. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2018).
- F. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2025a.
- G. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength; 2025.
- H. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2019.
- I. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- J. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2024a.

- K. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.
- L. UL (DIR) - Online Certifications Directory; Current Edition.
- M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.05 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

1.06 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of the Valve and Fitting Industry Inc.

1.07 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- 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 ACSE/SEI7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, systems contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.08 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for metal channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.09 QUALITY ASSURANCE

- A. Comply with applicable building code.

PART 2 PRODUCTS**2.01 GENERAL REQUIREMENTS**

- A. Provide required hardware to hang or support piping, equipment, or fixtures with related accessories as necessary to complete installation of plumbing work.
- B. Provide hardware products listed, classified, and labeled as suitable for intended purpose.
- C. Materials for Metal Fabricated Supports: Comply with Section 055000.
 - 1. Zinc-Plated Steel: Electroplated in accordance with ASTM B633 unless stated otherwise.
 - 2. Galvanized Steel: Hot-dip galvanized in accordance with ASTM A123/A123M or ASTM A153/A153M unless stated otherwise.
- D. Corrosion Resistance: Use corrosion-resistant metal-based materials fully compatible with exposed piping materials and suitable for the environment where installed.

2.02 BEAM CLAMPS

- A. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- B. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.

2.03 PIPE HANGERS

- A. Clevis Hangers, Adjustable:
 - 1. Copper Tube: MSS SP-58 type 1, epoxy-plated copper.
 - 2. Standard-Duty: MSS SP-58 type 1, zinc-colored, epoxy plated.

2.04 PIPE CLAMPS

- A. Riser Clamps:
 - 1. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
 - 2. MSS SP-58 type 1 or 8, carbon steel or steel with epoxy plated, plain, stainless steel, or zinc plated finish.
 - 3. UL (DIR) listed: Pipe sizes 1/2 to 8 inch.

2.05 PIPE SUPPORTS, GUIDES, SHIELDS, AND SADDLES

- A. Dielectric Barriers: Provide between metallic supports and metallic piping and associated items of dissimilar type; acceptable dielectric barriers include rubber or plastic sheets or coatings attached securely to pipe or item.
- B. Pipe Shields for Insulated Piping:
 - 1. MSS SP-58 type 40, ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
 - 2. General Construction and Requirements:
 - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
 - b. Shields Material: UV-resistant polypropylene with glass fill.
 - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
 - d. Service Temperature: Minus 40 to 178 degrees F.
 - e. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- C. Pipe Supports:

1. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
2. Liquid Temperatures Up to 122 degrees F:
 - a. Overhead Support: MSS SP-58 types 1, 3 through 12 clamps.
 - b. Support From Below: MSS SP-58 types 35 through 38.
- D. Pipe Supports, Thermal Insulated:
 1. General Requirements:
 - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
 - b. Pipe insulation protection shields to be provided at the hanger points and guide locations on pipes requiring insulation as indicated on drawings.
 - c. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
 - d. Provide pipe supports for 1/2 to 30 inch iron pipes.
 - e. Insulation inserts to consist of rigid phenolic foam insulation surrounded by 360 degree, PVC jacketing.
 2. PVC Jacket:
 - a. Pipe insulation protection shields to be provided with ball bearing hinge and locking seam.
 - b. Moisture Vapor Transmission: 0.0071 perm inch, when tested in accordance with ASTM E96/E96M.
 - c. Minimum Thickness: 60 mil, 0.06 inch.

2.06 ANCHORS AND FASTENERS

- A. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
- B. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
- C. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
- D. Preset Concrete Inserts: Continuous metal strut channel and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 1. Channel Material: Use galvanized steel.
 2. Manufacturer: Same as manufacturer of metal strut channel framing system.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- C. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.

- D. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- E. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- F. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.
- G. Equipment Support and Attachment:
 - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.
- I. Secure fasteners according to manufacturer's recommended torque settings.
- J. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION 220529

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**SECTION 220553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Pipe markers.

1.03 RELATED REQUIREMENTS

- A. Section 099123 - Interior Painting: Identification painting.

1.04 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2025.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Schedules:
 - 1. Submit plumbing component identification schedule listing equipment, piping, and valves.
 - 2. Detail proposed component identification data in terms of of wording, symbols, letter size, and color coding to be applied to corresponding product.
 - 3. Valve Data Format: Include id-number, location, function, and model number.

PART 2 PRODUCTS

2.01 PLUMBING COMPONENT IDENTIFICATION GUIDELINE

- A. Pipe Markers: 3/4 inch diameter and higher.

2.02 NAMEPLATES

- A. Manufacturers:
 - 1. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 - 2. Kolbi Pipe Marker Co; _____: www.kolbipipemarkers.com/#sle.
 - 3. Seton Identification Products; _____: www.seton.com/#sle.
- B. Description: Laminated piece with up to three lines of text.
 - 1. Letter Color: White.
 - 2. Letter Height: 1/4 inch.
 - 3. Background Color: Black.

2.03 TAGS

- A. Manufacturers:
 - 1. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 - 2. Kolbi Pipe Marker Co; _____: www.kolbipipemarkers.com/#sle.
 - 3. Seton Identification Products; _____: www.seton.com/#sle.
-

- 4. Substitutions: See Section 016000 - Product Requirements.
- B. Flexible: Vinyl with engraved black letters on light contrasting background color with up to three lines of text. Minimum tag size 1-1/2 inch in diameter.
- C. Valve Tag Chart: Typewritten 12-point letter size list in anodized aluminum frame.

2.04 PIPE MARKERS

- A. Manufacturers:
 - 1. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 - 2. Kolbi Pipe Marker Co; _____: www.kolbipipemarkers.com/#sle.
 - 3. Seton Identification Products; _____: www.seton.com/#sle.
- B. Comply with ASME A13.1.
- C. Flexible Marker: Factory fabricated, semi-rigid, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid conveyed.
- D. Identification Scheme, ASME A13.1:
 - 1. Primary: External Pipe Diameter, Uninsulated or Insulated.
 - 2. Secondary: Color scheme per fluid service.
 - a. Water; Potable, Cooling, Boiler Feed, and Other: White text on green background.

PART 3 EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive identification products.
- B. Prepare surfaces for stencil painting, see Section 099123.

3.02 INSTALLATION

- A. Install flexible nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags in clear view and align with axis of piping
- C. Apply stencil painted identification in compliance with Section 099123 requirements. Identify unit with assigned id-number and area being served using pipe marking rules.
- D. Install plastic pipe markers in accordance with manufacturer's instructions.
- E. Install plastic tape pipe marker around pipe in accordance with manufacturer's instructions.
- F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- G. Install labels and/or tags on all pipes as follows:

END OF SECTION 220553

**SECTION 220719
PLUMBING PIPING INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Flexible removable and reusable blanket insulation.
- B. Glass fiber insulation.
- C. Jacketing and accessories.
- D. Supplies and drains for hand
- E. Section includes insulating the following pipe systems
 - 1. Domestic Cold Water Piping
 - 2. Domestic Hot Water Piping
 - 3. Domestic recirculating hot water piping

1.02 RELATED REQUIREMENTS

- A. Section 099123 - Interior Painting: Painting insulation jacket.
- B. Section 221005 - Plumbing Piping: Placement of hangers and hanger inserts.

1.03 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2019, with Editorial Revision (2023).
- B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2024).
- C. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2025.
- D. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2022a.
- E. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2022.
- F. ASTM C585 - Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing; 2022.
- G. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2023).
- H. ASTM D2842 - Standard Test Method for Water Absorption of Rigid Cellular Plastics; 2025.
- I. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- J. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2024a.
- K. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

- B. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.
- C. Maintain ambient conditions required by manufacturers of each product.
- D. Maintain temperature before, during, and after installation for minimum of 24 hours.

1.05 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.
- C. Coordinate installation and testing of heat tracing.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER INSULATION

- A. Manufacturers:
 - 1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
 - 2. Johns Manville Corporation; _____: www.jm.com/#sle.
 - 3. Knauf Insulation: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation; Fiberglas Pipe Insulation ASJ: www.ocbuildingspec.com/#sle.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible, with wicking material to transport condensed water to the outside of the system for evaporation to the atmosphere.
 - 1. K Value: ASTM C177, 0.23 at 75 degrees F.
 - 2. Maximum Service Temperature: 220 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- C. Vapor Barrier Jacket: White Kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm.

2.03 JACKETING AND ACCESSORIES

- A. PVC Plastic Jacket:
 - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: 0 degrees F.
 - b. Maximum Service Temperature: 150 degrees F.
 - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil, 0.010 inch.
 - e. Connections: Brush on welding adhesive.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with North American Insulation Manufacturers Association (NAIMA) National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.
 - 1. Provide PVC jacket on all exposed piping up to 7' above finished floor (i.e. all piping at domestic hot water system and exposed vertical storm leaders).
- D. Insulated pipes conveying fluids below ambient temperature: Insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- E. Install cellular melamine with factory-applied jackets with a manufacturer-approved adhesive along seams, both straight lap joints and circumferential lap joints.
 - 1. Install seal over seams with factory-approved room temperature vulcanization (RTV) silicone sealant to ensure a positive vapor barrier seal in outdoor and sanitary washdown environments.
- F. Glass fiber insulated pipes conveying fluids below ambient temperature:
 - 1. Provide vapor barrier jackets, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
 - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- G. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- H. Inserts and Shields:
 - 1. Application: Piping 1-1/2 inches diameter or larger.
- I. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.03 INDOOR PIPING INSULATION SCHEDULE

- A. **Domestic Cold 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.
- B. **Domestic Hot and Recirculated Hot Water (105-140 F):**
 - 1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 - 2. NPS 1-1/2 and Larger: Insulation shall be one of the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.
- C. **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. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

- b. Manufactured system with PVC jacket equal to Truebro. Refer also to fixture specification.

D. Sanitary Waste Piping Where Heat Tracing Is Installed:

- 1. All Pipe Sizes: Insulation shall be the following:
 - a. Cellular Glass: 2 inches thick.

3.04 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
- D. Piping, Exposed:
 - 1. PVC: 20 mils thick.

END OF SECTION 220719

**SECTION 221005
PLUMBING PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Sanitary waste piping, buried beyond 5 feet of building.
- B. Sanitary waste piping, buried within 5 feet of building.
- C. Sanitary waste and vent piping, above grade.
- D. Sanitary Force Main piping
- E. Condensate piping
- F. Domestic water service, buried within 5 feet of building.
- G. Domestic water piping, above grade.
- H. Pipe flanges, unions, and couplings.

1.02 RELATED REQUIREMENTS

- A. Section 083100 - ACCESS DOORS AND PANELS.
- B. Section 099113 - Exterior Painting.
- C. Section 220516 - Expansion Fittings and Loops for Plumbing Piping.
- D. Section 220529 - Hangers and Supports for Plumbing Piping and Equipment.
- E. Section 220553 - Identification for Plumbing Piping and Equipment.
- F. Section 220719 - Plumbing Piping Insulation.
- G. Section 312316 - Excavation.
- H. Section 312323 - Fill.

1.03 REFERENCE STANDARDS

- A. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- C. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings: DWV; 2021.
- D. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings—DWV; 2022.
- E. ASME B31.9 - Building Services Piping; 2025.
- F. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings; 2025.
- G. ASTM B32 - Standard Specification for Solder Metal; 2020.
- H. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.
- I. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2020.
- J. ASTM B306 - Standard Specification for Copper Drainage Tube (DWV); 2020.
- K. ASTM B813 - Standard Specification for Water Flushable Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube; 2024.
- L. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings; 2016.

- M. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings; 2020a.
- N. ASTM C1277 - Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings; 2020.
- O. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- P. ASTM F876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing; 2026.
- Q. ASTM F877 - Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems; 2025.
- R. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings; 2023.
- S. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast; 2023.
- T. AWWA C651 - Disinfecting Water Mains; 2023.
- U. CISPI 301 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications; 2021.
- V. CISPI 310 - Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications; 2020.
- W. NSF 61 - Drinking Water System Components - Health Effects; 2025, with Addendum
- X. NSF 372 - Drinking Water System Components - Lead Content; 2024.
- Y. PPI TR-4 - PPI HSB Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe; 2024.
- Z. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.

1.05 QUALITY ASSURANCE

- A. Perform work in accordance with applicable codes.
- B. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.07 FIELD CONDITIONS

- A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Potable Water Supply Systems: Provide piping, pipe fittings, and solder and flux (if used), that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.

- B. Plenum-Installed Acid Waste Piping: Flame-spread index equal or below 25 and smoke-spread index equal or below 50 according to ASTM E84 or UL 723 tests.
- C. All Cast Iron Soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and listed by NSF International.
 - 1. Each length of pipe and each fitting shall be plainly marked with size, country of origin, and name of manufacturer or manufacturer's registered trademark

2.02 SANITARY WASTE PIPING, BURIED BEYOND 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74 extra heavy weight.
 - 1. Fittings: Cast iron.
 - 2. Joint Seals: ASTM C564 neoprene gaskets, or lead and oakum.

2.03 SANITARY WASTE PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Cast Iron Pipe: ASTM A74 extra heavy weight.
 - 1. Fittings: Cast iron.
 - 2. Joints: Hub-and-spigot, CISPI HSN compression type with ASTM C564 neoprene gaskets.

2.04 SANITARY SEWER AND SANITARY VENT PIPING, ABOVE GRADE

- A. Cast Iron Pipe: CISPI 301, hubless, service weight.
 - 1. Fittings: Cast iron.
 - 2. Joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.
- B. Copper Tube: ASTM B306, DWV.
 - 1. Fittings: ASME B16.29, wrought copper, or ASME B16.23, solvent.
 - 2. Joints: ASTM B32, alloy Sn50 solder.
- C. Copper Tube: ASTM B88 (ASTM B88M), Type K (A).
 - 1. Fittings: ASME B16.29, wrought copper, or ASME B16.23, solvent.
 - 2. Joints: ASTM B32, alloy Sn50 solder.

2.05 SANITARY FORCE MAIN PIPING, ABOVE GRADE

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A).
 - 1. Fittings: ASME B16.29, wrought copper, or ASME B16.23, solvent.
 - 2. Joints: ASTM B32, alloy Sn50 solder.

2.06 CONDENSATE PIPING

- A. Copper Tube: ASTM B306, DWV.
 - 1. Fittings: ASME B16.29, wrought copper, or ASME B16.23, solvent.
 - 2. Joints: ASTM B32, alloy Sn50 solder.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B).
 - 1. Fittings: ASME B16.29, wrought copper, or ASME B16.23, solvent.
 - 2. Joints: ASTM B32, alloy Sn50 solder.

2.07 DOMESTIC WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Ductile Iron Pipe: AWWA C151/A21.51.
 - 1. Cement Mortar lining AWWA C104.
 - 2. Fittings: AWWA C110/A21.10. Ductile iron, Class 52 thickness. Cement lined.
 - 3. Joints: AWWA C111/A21.11, styrene butadiene rubber (SBR) or vulcanized SBR gasket with 3/4 inch diameter rods.

2.08 DOMESTIC WATER PIPING, BURIED WITHIN BUILDING (I.E. TO ISLAND SINK)

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), Coil length required for underslab, no joints.
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - 2. Joints: ASTM B32, alloy Sn95 solder.
 - a. No joints below slab. Route within PVC conduit, with joints just above slab.
- B. Cross-Linked Polyethylene (PEX) Pipe: ASTM F876 or ASTM F877.
 - 1. Manufacturers:
 - a. Uponor, Inc; _____: www.uponorengineering.com/#sle.
 - 2. PPI TR-4 Pressure Design Basis:
 - a. 160 psig at maximum 73 degrees F.
 - 3. Joints: Mechanical compression fittings.
 - a. No joints below slab. Route within PVC conduit, with joints just above slab

2.09 DOMESTIC WATER PIPING, ABOVE GRADE

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), Drawn (H).
 - 1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - 2. Joints: ASTM B32, alloy Sn95 solder.

2.10 PIPE FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 inch and Under:
 - 1. Ferrous Pipe: Class 150 malleable iron threaded unions.
 - 2. Copper Tube and Pipe: Class 150 bronze unions with soldered joints.
- B. No-Hub Couplings:
 - 1. Testing: In accordance with ASTM C1277 and CISPI 310.
 - 2. NSF Certification
 - 3. Gasket Material: Neoprene complying with ASTM C564.
 - 4. Band Material: Stainless steel.
 - 5. Eyelet Material: Stainless steel.
 - 6. Manufacturers:
 - a. MIFAB, Inc; MI-QHUB: www.mifab.com/#sle.
 - b. Charlotte Pipe and Foundry
 - c. Ideal Tridon

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that excavations are to required grade, dry, and not over-excavated.

3.02 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.03 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C. Install piping to maintain headroom, conserve space, and not interfere with use of space.

- D. Group piping whenever practical at common elevations.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. See Section 220516.
- F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- G. Provide access where valves and fittings are not exposed.
 - 1. Coordinate size and location of access doors with Section 083100.
- H. Establish elevations of buried piping outside the building to ensure not less than 5 ft of cover for pipes that require freeze protection.
- I. Install vent and gas piping penetrating roofed areas to maintain integrity of roof assembly and to comply with manufacturer warranty.
- J. Prepare exposed, unfinished pipe, fittings, supports, and accessories for finish painting.
 - 1. See Section 099113 for painting of exterior plumbing systems and components.
- K. Excavate in accordance with Section 312316.
- L. Backfill in accordance with Section 312323.
- M. Install valves with stems upright or horizontal, not inverted. See Section 220523.
- N. Install water piping to ASME B31.9.
- O. Copper Pipe and Tube: Make soldered joints in accordance with ASTM B828, using specified solder, and flux meeting ASTM B813; in potable water systems use flux also complying with NSF 61 and NSF 372.
- P. Sleeve pipes passing through partitions, walls, and floors.
- Q. Pipe Hangers and Supports:
 - 1. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- R. Pipe Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Locate piping in center of sleeve or penetration.
 - 4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
 - 5. Tighten bolting for a watertight seal.
 - 6. Install in accordance with manufacturer's recommendations.

3.04 APPLICATION

- A. Install unions downstream of valves and at equipment or apparatus connections.
- B. Install ball or butterfly valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- C. Provide lug end butterfly valves adjacent to equipment when provided to isolate equipment.
- D. Provide spring-loaded check valves on discharge of water pumps.

3.05 FIELD TESTS AND INSPECTIONS

- A. Verify and inspect systems according to requirements by the Authority Having Jurisdiction. In the absence of specific test and inspection procedures proceed as indicated below.
- B. Test Sanitary waste and vent piping according to procedures of AHJ 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. If testing is performed in segments, submit separate report for each test.
 - 2. Leave piping uncovered and unconcealed new, altered, extended or replaced waste and vent piping until it has been tested, inspected and approved.
 - 3. Rough-in Plumbing test Procedure:
 - 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.
- C. Domestic Water Systems:
 - 1. Perform hydrostatic testing for leakage prior to system disinfection.
 - 2. Test Preparation: Close each fixture valve or disconnect and cap each connected fixture.
 - 3. General:
 - a. Fill the system with water and raise static head to 10 psi above service pressure. Minimum static head of 50 to 150 psi. As an exception, certain codes allow a maximum static pressure of 80 psi.
- D. Test Results: Document and certify successful results, otherwise repair, document, and retest.

3.06 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Prior to starting work, verify system is complete, flushed, and clean.
- B. Ensure acidity (pH) of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- C. Inject disinfectant, free chlorine in liquid, powder, tablet, or gas form throughout system to obtain 50 to 80 mg/L residual.
- D. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- E. Maintain disinfectant in system for 24 hours.
- F. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- G. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- H. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.

3.07 DISINFECTION OF DOMESTIC WATER PIPING - NYS DOH

- A. Clean and disinfect potable domestic water piping as follows:
 - 1. Purge new piping and parts of the existing piping that have been altered, extended, or repaired, before putting back into use.
 - 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. OR
 - 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 (above normal potable water limites) is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water sampes in sterile bottles to NYS Department of Health approved lab with results sent to the DOH and to the architect/engineer of record as project submittal.
- B. Prepare and submit reports of purging and disinfecting activities. Include copies of water sample approval from NYS Department of Health approved lab.
- C. Where new fixture have been added to nYS K-12 school buildings, test samples shall be taken at all new fixtures in accordance with SED testing protocol for Lead. Submit test results to Arch/Engineer./District.

3.08 SERVICE CONNECTIONS

- A. Provide new sanitary sewer services. Before commencing work, check invert elevations required for sewer connections, confirm inverts and ensure that these can be properly connected with slope for drainage and cover to avoid freezing.
- B. Provide new water service complete with approved reduced pressure backflow preventer and water meter with by-pass valves, pressure reducing valve, and sand strainer.
 - 1. Provide sleeve in wall for service main and support at wall with reinforced concrete bridge. Calk enlarged sleeve and make watertight with pliable material. Anchor service main inside to concrete wall.

END OF SECTION 221005

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**SECTION 221006
PLUMBING PIPING SPECIALTIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Floor Drains.
- B. Cleanouts.
- C. Hose bibbs.
- D. Backflow preventers.
- E. Water hammer arrestors.
- F. Sanitary waste interceptors.

1.02 REFERENCE STANDARDS

- A. ASME A112.6.3 - Floor Drains; 2022.
- B. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings—DWV; 2022.
- C. ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies; 2021.
- D. ASSE 1019 - Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance; 2023.
- E. NSF 61 - Drinking Water System Components - Health Effects; 2025, with Addendum
- F. NSF 372 - Drinking Water System Components - Lead Content; 2024.

1.03 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- C. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.
- D. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- E. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- F. Project Record Documents: Record actual locations of equipment, cleanouts, backflow preventers, and water hammer arrestors.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements for additional provisions.
 - 2. Extra Loose Keys for Outside Hose Bibbs: One.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Accept specialties on site in original factory packaging. Inspect for damage.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS - ALSO REFER TO FIXTURE SCHEDULE ON PLANS FOR MAKE/MODEL

- A. Specialties in Potable Water Supply Systems: Provide products that comply with NSF 61 and NSF 372 for maximum lead content.

2.02 DRAINS

- A. Floor Drains:
1. Manufacturers:
 - a. Jay R. Smith Manufacturing Company: www.jrsmith.com/#sle.
 - b. Josam
 - c. MIFAB, Inc: www.mifab.com/#sle.
 - d. Zurn Industries, LLC: www.zurn.com/#sle.
 - e. Watts
- B. Floor Drain - Finished area/Toilet room/Shower (FD-1):
1. ASME A112.6.3; lacquered cast iron or stainless steel, two piece body with double drainage flange, weep holes, reversible clamping collar, and round, adjustable nickel-bronze strainer.
- C. Floor Sink FS-1:
1. ASME A112.6.3; _____ stainless steel, two piece body with double drainage flange, weep holes, reversible clamping collar, and 10+" square stainless steel extra heavy duty strainer with 3/4 grate and removable sediment bucket.
 2. Set with cover flush to finished floor, in accessible location, but not in the normal path of travel.

2.03 CLEANOUTS

- A. Manufacturers:
1. Jay R. Smith Manufacturing Company; _____: www.jrsmith.com/#sle.
 2. Josam Company; _____: www.josam.com/#sle.
 3. MIFAB, Inc; C1100-R: www.mifab.com/#sle.
 4. Zurn Industries, LLC; _____: www.zurn.com/#sle.
 5. Watts
- B. Cleanouts at Interior Finished Floor Areas FCO:
1. Galvanized cast iron body with anchor flange, reversible clamping collar, threaded top assembly, and round gasketed scored Nickel Bronze cover in service areas and hard surface finished floors and round gasketed depressed cover to accept floor finish in carpeted floor areas.
- C. Cleanouts at Interior Finished Wall Areas WCO:
1. Line type with lacquered cast iron body and round epoxy coated gasketed cover, and round stainless steel access cover secured with machine screw.
- D. Cleanouts at Interior Unfinished Accessible Areas CO: Calked or threaded type. Provide bolted stack cleanouts on vertical rainwater leaders.

2.04 BACKFLOW PREVENTERS

- A. Reduced Pressure Backflow Preventer Assembly:
1. ASSE 1013 and NSF 61 compliant Lead Free Cast Iron body and stainless steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve that opens under

back pressure in case of diaphragm failure, integral male test fittings, and non-threaded vent outlet.

2. Size: 3/4 to 2 inch assembly with threaded full port ball valves.
3. Size: 2-1/2" to 8" inch assembly with threaded gate valves.
4. Maximum Working Parameters: 175 psi at 180 degrees F.
5. Accessories: Provide lead-free Y-strainer and test cocks.

2.05 SANITARY WASTE INTERCEPTORS

- A. Manufacturers:
 1. Schier.
 2. Jay R. Smith Manufacturing Company.
 3. MIFAB, Inc.
 4. Zurn Industries, LLC.
- B. Grease Interceptors:
 1. Construction:
 - a. Material: High-density polyethylene.
 - b. Rough-in: Fully recessed flush with floor (deep rough-in) with anchor flange.
 - c. Cover: Steel, epoxy coated, non-skid with gasket, securing handle, and enzyme injection port, recessed for floor finish. Meet NYS regulations for weight and securing.
 2. Unit Rating: 250 gpm flow and 500 lbs grease capacity.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install floor drains at low point in floor. Corrdinate final "flush to finished floor" drain cover elevation with GC flooring installer. If entire floor is not pitched to floor drain, create 2' diameter low point at drain, pitched ~1/8"/foot.
- C. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance at cleanout for rodding of drainage system.
- D. Install floor cleanouts at elevation to accommodate finished floor.
- E. Install approved potable water protection devices on plumbing lines where contamination of domestic water may occur; on boiler feed water lines, janitor rooms, fire sprinkler systems, premise isolation, irrigation systems, flush valves, interior and exterior hose bibbs.
- F. Pipe relief from backflow preventer to nearest drain.
- G. Install water hammer arrestors complete with accessible isolation valve on hot and cold water supply piping to lavatory sinks, washing machine outlets, or any fast closing fixtures/valves.

END OF SECTION 221006

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**SECTION 221123
DOMESTIC WATER PUMPS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Circulators.

1.02 RELATED REQUIREMENTS

- A. Section 220513 - Common Motor Requirements for Plumbing Equipment.
- B. Section 260583 - Wiring Connections.

1.03 REFERENCE STANDARDS

- A. ICC (IPC) - International Plumbing Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. NSF 61 - Drinking Water System Components - Health Effects; 2025, with Addendum

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data:
 - 1. Provide certified pump curve with duty point marked over pump and system operating conditions and NPSH curve and power requirement by pump tag.
- C. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. See Section 017419 - Construction Waste Management and Disposal for packaging waste requirements.
- B. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.06 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer Warranty: Provide 2-year manufacturer warranty for circulators. Complete forms in Owner's name and register with manufacturer.

PART 2 PRODUCTS

2.01 CIRCULATORS RP-1 - REFER ALSO TO PLUMBING EQUIPMENT SCHEDULE

- A. Manufacturers:
 - 1. Armstrong Fluid Technology; _____: www.armstrongfluidtechnology.com/#sle.
 - 2. Bell & Gossett, a Brand of Xylem, Inc; _____: www.xylem.com/#sle.
 - 3. Grundfos Pumps Corporation: www.grundfos.com/#sle.
 - 4. Taco, Inc; _____: www.tacomfort.com/#sle.
- B. Casing: Bronze with bronze cast impeller, and stainless steel rotor assembly.
- C. Shaft: Alloy steel with integral thrust collar and two oil-lubricated bronze sleeve bearings.
- D. Mechanical Seal: Carbon rotating against a stationary ceramic seat.
- E. Pipe-End Connection: Union connection.
- F. Maximum Discharge Pressure: 145 psi.

- G. Motor: 1,750 rpm, 3-speed squirrel cage with flexible coupling.
- H. Service Temperature Range: Minus 30 to 250 degrees F.
- I. Controls: Provide aquastat set for high-temp cutoff, electric plug, and time clock set for business hours.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install products with related fittings, and accessories according to manufacturer instructions.
- B. Potable and Drinking Water Service: Provide NSF 61 certified; comply with ICC (IPC).
- C. Electrical-Driven Pump Work:
 - 1. Provide electric-motor-driven equipment specified complete with local disconnect switch and control panel with starter, controls, safety devices, and related wiring.
 - 2. Provide automatic control and protective devices field-wired to interface-related devices required for specified operation.
- D. Ensure that small pressure gauges are installed on both upstream and downstream ends.
- E. Hot Water Service: Ensure that small pressure-temperature gauges are installed on both upstream and downstream ends.
- F. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are nonoverloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.
- B. Operational Tests: Upon completion and sterilization of plumbing systems, conduct operating tests to demonstrate satisfactory, functional, and operating efficiency.

3.03 CLEANING

- A. Thoroughly clean plumbing fixtures and equipment.
- B. See Section 017419 - Construction Waste Management and Disposal for additional requirements.

END OF SECTION 221123

**SECTION 221429
SUMP PUMPS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Elevator Submersible sump pumps.
- B. Sump basins and pits.

1.02 REFERENCE STANDARDS

- A. ICC (IPC) - International Plumbing Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. UL (DIR) - Online Certifications Directory; Current Edition.

1.03 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide certified pump chart or curve with duty point marked over.
- C. Shop Drawings: Include dimensions and performance data.
- D. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

1.04 QUALITY ASSURANCE

- A. Certifications: UL (DIR) listed, classified, and suitable for the purpose specified and indicated.
- B. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.06 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer Warranty: Provide 1-year manufacturer warranty for pumps and related components. Complete forms in Owner's name and register with manufacturer.
- C. Submit warranty with related forms completed in Owner's name and registered with manufacturer.

PART 2 PRODUCTS

2.01 SUBMERSIBLE SUMP PUMPS

- A. Manufacturers:
 - 1. Liberty Pumps.
 - 2. Stancor.
 - 3. Zoeller.
- B. General: Rugged stainless steel and cast iron housing and base with oil-filled motor chamber, ball bearings, and mechanical seal.
- C. Impeller: Thermoplastic; open nonclog, stainless steel shaft.
- D. Motor: Base mount, enclosed, lubricated oil-free, thermal-overload protected, continuous duty, permanent split capacitor with oil-resistant, three-prong connector, 10 foot power cord.

- E. Controls: Simplex elevator sump pump controller with oil detector to prevent pumping of oil from the sump.
- F. Solids Handling Capacity: Pass lint and other small solids up to 3/4 min inch in size.
- G. Discharge Pipe Size: 1-1/2 inch, NPT, female.
- H. Maximum Water-Based Effluent Temperature: 120 degrees F.
- I. Accessories: Provide full flow swing-type discharge check valve.

2.02 SUMP BASINS AND PITS

- A. Sump Basin:
 - 1. Manufacturers:
 - a. Liberty Pumps.
 - b. Stancor.
 - c. Zoeller.
 - 2. Basin Dimensions: 24 inch diameter, 30 inch deep.
 - 3. Basin Material: Polyethylene structural foam, heavy duty injection molded.
 - 4. Molded-Finish Requirements: Hard bottom, watertight, gas-tight and radon-tight molding.
 - 5. Maximum Effluent Temperature: Match or exceed maximum pump service temperature.
 - 6. Basin Riser Extension: Diameter matched, 6 inch with hardware.
 - 7. Basin Cover:
 - a. Material: One-piece flat lid made of polyethylene unsealed.
 - b. Openings: 1-1/2 inch discharge and cord grommet with hubs.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install products with related fittings and accessories according to manufacturer instructions.
- B. Observe and provide incidentals required to complete installation in compliance with ICC (IPC).

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.
- B. Operational Tests: Conduct operating tests to demonstrate satisfactory, functional, and operating efficiency.

END OF SECTION 221429

**SECTION 223000
PLUMBING EQUIPMENT**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

- A. Commercial indirect-fired water heaters.
- B. Mixing Valves.
- C. Electrical Equipment Disconnect

1.03 RELATED REQUIREMENTS

- A. Section 251500 - Integrated Automation Software.

1.04 REFERENCE STANDARDS

- A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); Current Edition.
- B. ANSI Z21.10.1 - Gas Water Heaters, Volume I, Storage Water Heaters with Input Ratings of 75,000 Btu per Hour or Less; 2019 (Reaffirmed 2024).
- C. ANSI Z21.10.3 - Gas-Fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous; 2019 (Reaffirmed 2024).
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. ICC (IPC) - International Plumbing Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data:
 - 1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
 - 2. Provide electrical characteristics and connection requirements, including any required disconnects.
- C. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- D. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- E. Project Record Documents: Record actual locations of components.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements for additional provisions.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Certifications:
 - 1. Water Heaters: NSF approved.
 - 2. Indirect-Fired Gas Water Heaters: AHRI Directory of Certified Product Performance.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.08 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.

PART 2 PRODUCTS

2.01 WATER HEATERS (WH-1)

- A. Water Heater:
- B. Commercial Indirect-Fired Domestic Water Heaters - refer to schedule on plans:
 - 1. Manufacturers:
 - a. Lochinvar.
 - b. Bradford White Corporation.
 - 2. Type: Automatic, indirect-fired, vertical storage.
 - 3. Minimum Efficiency Required: ASHRAE Std 90.1 I-P.
 - 4. Tank: Glass lined welded steel ASME labeled; multiple flue passages, 4 inch diameter inspection port, thermally insulated with minimum 2 inches glass fiber, encased in corrosion-resistant steel jacket; baked-on enamel finish; floor shield and legs.
 - 5. Coordinate with Mechanical Contractor for connection to boiler water to heat exchanger.
 - 6. Accessories:
 - a. Water Connections: Brass.
 - b. Dip Tube: Brass.
 - c. Drain valve.
 - d. Anode: Magnesium.
 - e. Temperature and Pressure Relief Valve: ASME labeled.
 - 7. Applications:
 - a. Automatic storage water heater.
 - b. For operation at 140 degrees F.
 - c. 400 gallon jacketed Horizontal storage tank.
 - d. Double wall Heat Exchanger rated for 429 GPH recovery at 80F rise (279 GPH @ 100F) at 180F boiler water.

2.02 MIXING VALVES (MV-1)

- A. Thermostatic Master Tempering Valves:
 - 1. Manufacturers: Subject to compliance requirements, available manufacturers offering products that may be incorporated into the work include, but are not limited to, the following:
 - a. Leonard Valve Company; _____: www.leonardvalve.com/#sle.
 - b. Powers, A Watts Brand. **Equal to LFSH1434**
 - c. Lawler Valve Co.
 - d. Substitutions: See Section 016000 - Product Requirements.

2. Valve: Chrome plated cast brass body, stainless steel or copper alloy bellows, integral temperature adjustment.
3. Capacity: 85 gpm at 20 psi differential.
4. Low flow 1 gpm
5. Accessories:
 - a. Shut off & Check valve on inlets.
 - b. Volume control shut-off valve on outlet.
 - c. Stem thermometer on outlet.
 - d. Strainer stop checks on inlets.

2.03 BALANCE VALVES

- A. Body: Lead-Free Brass.
- B. Ball: 304 Stainless Steel.
- C. Seat Rings: Glass and Carbon filled TFE.
- D. Readout Valves: Brass with EPT check valves.
- E. Stem "O" Ring: EPDM.

2.04 IN-LINE CIRCULATOR PUMPS (RP-1)

- A. Recirculation 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. Armstrong Fluid Technology; _____: www.armstrongfluidtechnology.com/#sle.
 2. Bell & Gossett, a brand of Xylem, Inc; _____: www.bellgossett.com/#sle.
 3. PACO Pumps; Grundfos Pump Corporation, USA _____.
 4. Substitutions: See Section 016000 - Product Requirements.
- C. Casing: Bronze, rated for 125 psig working pressure, with stainless steel rotor assembly.
- D. Impeller: Bronze.
- E. Controller: Honeywell Aquastat model **L4006A2007-U**
- F. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.
- G. Seal: Carbon rotating against a stationary ceramic seat.
- H. Drive: Flexible coupling.
- I. Performance:
 1. Flow: 20 gpm, at 22 feet head.
 2. Confirm and Match existing pump flow/head settings
 3. Electrical Characteristics:
 - a. 120 volts, single phase, 60 Hz,

2.05 ELECTRICAL WORK

- A. Provide electrical motor driven equipment specified complete with motors, motor starters, controls, disconnects and wiring.
- B. Disconnect shall be rated and sized for the associated piece of equipment. Coordinate with electrical contract for power connection.
- C. Electrical characteristics to be as specified or indicated.

- D. Furnish motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified.
- E. Supply manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices not shown.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions required for applicable certifications.
- B. Electrical Work: Provide automatic control and protective devices with associated wiring to interconnect related interfaced devices required for specified operation.
- C. Coordinate with plumbing piping and related fuel piping work to achieve operating system.
- D. Ensure building domestic water circulation is functional equivalent to existing at start-up.
- E. Domestic Water Heat Exchangers:
 - 1. Install domestic water heat exchangers with clearance for tube bundle removal without disturbing other installed equipment or piping.
 - 2. Pipe relief valves and drains to nearest floor drain.
- F. Domestic Water Storage Tanks:
 - 1. Provide steel pipe support, independent of building structural framing members.
 - 2. Clean and flush prior to delivery to site. Seal until pipe connections are made.

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.
- B. Coordinate BAS, BMS, or Integrated Automation linking between unit controller(s) and remote front-end interface; see Section 251500.

END OF SECTION 223000

SECTION 230000
GENERAL PROVISIONS FOR MECHANICAL WORK

PART 1 - GENERAL**1.01 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of this Section apply to work in every Section of Division 23 equally as if incorporated therein.

1.02 WORK INCLUDED

- A. Work included in Division 23 - Mechanical: Materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for Mechanical Work covered by all sections within this Division.

1.03 SCOPE

- A. Division of the Specification into sections is for the purpose of simplification alone. Responsibility for the work of various trades shall rest with the Contractor. Various sections of this Division are related to each other as well as the mechanical drawings. Examine all drawings and read all applicable parts of the project manual in order to ensure complete execution of all work in this Division, coordinating where required with other trades in order to avoid conflicts.
- B. These specifications and accompanying drawings are intended to cover the furnishing of all labor, materials, equipment and services necessary for the complete installation and acceptable performance of the mechanical systems. Small items of material, equipment and appurtenances not mentioned in detail or shown on the drawings, but necessary for complete and operating systems shall be provided by this contractor without additional charge to the Owner and shall be included under this contract.
- C. In general, specifications establish the quality of material, equipment and workmanship. The contract documents are intended to secure for the Owner, a first-class installation in every respect. Labor shall be performed by skilled mechanics, and the entire facility, when delivered to the Owner, shall be ready for satisfactory and efficient operation.
- D. The Contractor shall carefully examine the drawings and specifications before accepting the contract. He shall call attention to any changes or additions which, in his opinion, are necessary to make possible the fulfillment of any guarantee called for by these specifications; failing which, it shall be deemed that he has accepted full responsibility for all such guarantees.
- E. The contractor shall put his work in place as fast as is reasonably possible. He shall, at all times, keep a competent foreman in charge of the work, to make decisions necessary for the diligent advancement of the work. The Contractor shall facilitate the inspection of the work by the Owner's Representative.
- F. The Contractor shall coordinate all work in the building in order to facilitate intelligent execution of the work. He shall also remove any rubbish as expeditiously as possible.
- G. Materials or products specified herein and/or indicated on the drawings by trade's names, manufacturer's names, model number or catalog numbers establish the quality of materials or products to be furnished. Model numbers are to be confirmed by the manufacturer to provide required capacities and material to meet the specifications and design intent. In no instance

shall an obsolete, incomplete or inaccurate trade name, manufacturer name, model number or catalog number indicated on the drawings, result in additional charges to the owner.

- H. Points of connection or continuation of work under this contract are so marked on drawings or herein specified. In case of any doubt as to the required exact location of such points, the Owner's Representative shall decide and direct.
- I. The plumbing contractor shall provide water services to within two (2) feet of HVAC equipment requiring same, and shall terminate service with a shutoff valve. The mechanical contractor shall make the final connection to the equipment.

1.04 TEMPERATURE CONTROL AND INSTRUMENTATION FOR HVAC

- A. The Mechanical Contractor is responsible for all Temperature Control and Instrumentation for all HVAC systems.
- B. All new controls installed in this project shall be an extension of the existing TBS Controls / Stark Tech control system.
- C. All analog and binary inputs and outputs (points) shown on H Series drawings or described in Section 230993 "Sequence of Operations for HVAC Controls" are considered a requirement of Division 23 and are to be provided by this contractor. All points are to be provided whether provided through manufacturer provided controllers, through the Building Automation System (BAS) or a combination of both. If equipment is being controlled by manufacturer controllers and a point(s) is not provided through the manufacturer controller, that point(s) shall be provided through the BAS system. All points are required to be integrated into the BAS, with full functionality by the end user, regardless of source. The BAS provider shall be responsible for the integration and functionality of all points. All points are also required to be shown in final system graphics.
- D. The Building Automation System (BAS) manufacturer shall furnish and install direct digital control (DDC) controls fully integrated into the Owners existing Building Automation System. The controls shall incorporate DDC for energy management, equipment monitoring, control, and subsystems as herein specified. All new equipment shall be controlled by the BAS system. The installing manufacturer shall certify in writing, that the equipment manufacturer has prepared the shop drawings and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that their company prepared the shop drawings and that all temperature control equipment was installed under their direct supervision.
- E. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
- F. The BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes.
- G. The new controls being provided as part of this project must be completely compatible in all respects with the existing HVAC systems and equipment that are currently installed. It shall be the responsibility of the temperature controls contractor to meet the requirements of Sections 230913 "Instrumentation and Control Devices for HVAC", 230923 "Direct-Digital Control System for HVAC", 230993 "Sequence of Operations for HVAC Controls", and all H Series drawings with respect to controls, control components and control sequences.
- H. The removal of any existing component (not to be re-used) shall include the removal of all associated wiring, conduit and support attachments. Where existing-to-remain finishes are

damaged as a result of the removal of any existing control equipment or where the removal exposes a previously damaged finish, the contractor shall repair the finish to match existing.

1.05 REFERENCE STANDARDS, CODES AND REGULATIONS

A. Requirements of Regulatory Agencies:

1. Nothing contained in these specifications or shown on the drawings shall be construed to conflict with any State or local laws, ordinances, rules and regulations, the UL and NFPA regulations. The Contractor shall make all changes required by the enforcing authorities. Where alterations to and / or deviations from the Contract Documents are required by the authorities having jurisdiction, report the requirements to the Engineer and secure acceptance before work is started. All such changes shall be made in a manner acceptable to the Engineer and shall be made without cost to the Owner.
2. When drawings or specifications exceed requirements of applicable laws, ordinances, rules and regulations, comply with documents establishing the more stringent requirement. All work shall be done in full conformity with the requirements of all authorities having jurisdiction. Installation shall be made in compliance with all applicable regulations, and utility company rules, all of which shall be considered a part of this specification and shall take precedence in the order of listing.
3. It is not the intent of drawings or specifications to repeat requirements of codes except where necessary for completeness in individual sections.

B. Published specifications, standards, tests or recommended method of trade, industry or governmental organizations as listed below apply to all work in this Division, in addition to other standards which may be specified in individual sections:

1. Associated Air Balance Council
2. Air Diffuser Balance Council
3. Air Moving and Conditioning Association
4. American Gas Association
5. American National Standards Institute
6. Air Conditioning and Refrigeration Institute
7. American Society of Heating, Refrigeration and Air Conditioning Engineers
8. American Society of Mechanical Engineers
9. American Society for Testing and Materials
10. Cast Iron Soil Pipe Institute
11. ETL Testing Laboratories
12. Factory Mutual Engineering and Research Corporation
13. National Standard Plumbing Code
14. National Electrical Manufacturer's Association
15. National Fire Protection Association
16. National Board of Fire Underwriters
17. National Electric Code
18. Occupational Safety and Health Administration
19. Plumbing Drainage Institute
20. Sheet Metal & Air Conditioning Contractors National Association
21. Underwriters Laboratories, Inc.

C. Furnish and file with the proper authorities, all drawings required by them in connection with the work. Contractor shall secure and obtain all approvals, permits, licenses and inspections and pay all legal and proper fees and charges in this connection, before commencing work in order

to avoid delays during construction. He shall deliver the official records of the granting of the permits, etc., to the Owner's Representative.

1.06 QUALITY ASSURANCE

- A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.
- B. Supply all equipment and accessories new and free from defects.
- C. Supply all equipment and accessories in compliance with the applicable standards listed in Article 1.4 of this section with all applicable national, state and local codes.
- D. All items of a given type shall be the product of same manufacturer.

1.07 DESCRIPTION OF BID DOCUMENTS

- A. Specifications:
 - 1. Specifications, in general, describe quality and character of materials and equipment.
 - 2. Specifications are of simplified form and include incomplete sentences.
 - 3. Words or phrases such as "The Contractor shall", "shall be", "furnish", "provide", "a", "an", "the", and "all" may have been omitted for brevity.
- B. Drawings: Mechanical drawings under this contract are made a part of these specifications. Deviations from these specifications as noted below must have the approval of the Engineer or Construction Manager without an increase in contract price.
 - 1. The drawings shall be considered as being diagrammatic and for bidding purposes only. Intention is to show size, capacity, approximate location, direction and general relationship of one work phase to another, but not exact detail or arrangement. The attention of the contractor is called to the fact that while these drawings are generally to scale and are made as accurately as the scale will permit, all critical dimensions shall be determined in the field. They are not to be considered as erection drawings.
 - 2. The drawings do not indicate every fitting, elbow, offset, valve, etc. which is required to complete the job. Contractor shall prepare field erection drawings as required for the use of his mechanics to insure proper installation.
 - 3. Scaled and figured dimensions are approximate and are for estimating purposes only. Indicated dimensions are limiting dimensions.
 - 4. Before proceeding with work check and verify all dimensions in field.
 - 5. Assume all responsibility for fitting of materials and equipment to other parts of equipment and structure.
 - 6. Make adjustments that may be necessary or requested in order to resolve space problems, preserve headroom, and avoid architectural openings, structural members and work of other trades.
 - 7. For exact locations of building elements, refer to dimensional Architectural/Structural drawings.
- C. Description of systems: Provide all materials to provide functioning systems in compliance with performance requirements specified, and any modifications resulting from reviewed shop drawings and field coordinated drawings.
 - 1. Installation of all systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination drawings.
- D. Do not use equipment exceeding dimensions indicated or equipment or arrangements that reduce required clearances or exceed specified maximum dimensions.

- E. If any part of Specifications or Drawings appears unclear or contradictory, apply to Architect for his interpretation and decision as early as possible, including during bidding period.
 - 1. Do not proceed with work without Engineer's decision.

1.08 EQUIPMENT MANUFACTURERS

- A. The first named manufacturer is used as the basis of design. Other named manufacturers are identified as equivalent manufacturers, not equivalent products. Naming other manufacturers does not necessarily imply conformance of any specific product with the written specifications.
- B. The contractor is required to verify that equipment and material to be used on the project meets the requirements of the specifications and will physically fit the available space, clearance and service requirements of the particular piece of equipment and include all pertinent information when he submits material for acceptance. Contractor shall also be responsible for and bear the cost of any modifications to openings available or anticipated as being available for rigging equipment to its final installation place. This shall include openings in exterior envelope, walls and roofs, interior walls, corridors, passage ways or door openings. Any on site dismantling and any reassembly of equipment made necessary by impediment to the rigging of said equipment shall be the sole responsibility of the contractor.
- C. Contract document indicates power and physical requirements based on the equipment manufacturer's data as first named. If equipment requiring more system capacity is furnished, the contractor shall be responsible for the cost associated with modifying the design and installation of associated services, including any redesign costs associated with the engineer's review.

1.09 DEFINITIONS

- A. "Provide": To supply, furnish, install and connect up complete and ready safe and regular operation of particular work referred to unless specifically noted.
- B. "Install": To erect, mount and connect complete with related accessories.
- C. "Supply", "Furnish": To purchase, procure, acquire and deliver complete with related accessories.
- D. "Work": Labor, materials, equipment, apparatus, controls, accessories, and other items required for proper and complete installation.
- E. "Piping": Pipe, tube, fittings, flanges, valves, controls, strainers, hangers, supports, unions, traps, drains, insulation, and related items.
- F. "Wiring": Raceway, fittings, wire, boxes and related items.
- G. "Concealed": Items referred to as hidden from normal sight, embedded in masonry or other construction, installed in furred spaces, within double partitions or hung ceilings, in trenches, in crawl spaces, or in enclosures.
- H. "Exposed": Not installed underground or "concealed" as defined above.
- I. "Indicated", "Shown", or "Noted": As indicated, shown or noted on drawings or specifications.
- J. "Directed": Directed by Engineer.
- K. "Similar" or "Equal": Of base bid manufacture, equal in materials, weight, size, design, and efficiency of specified product.
- L. "Reviewed", "Satisfactory", or "Directed": As reviewed, satisfactory, or directed by or to Engineer.

- M. "Motor Controllers": Manual or magnetic starters (with or without switches), individual pushbuttons or hand-off-automatic (HOA) switches controlling the operation of motors.
- N. "Control or Actuating Devices": Automatic sensing and switching devices such as thermostats, pressure, float, electro-pneumatic switches and electrodes controlling operation of equipment.
- O. "Remove": Dismantle, demolish and take away from the site and dispose of in accordance with all applicable rules and regulations or, should the Owner so require, deliver to a location as designated by the Owner for the use of the Owner, at no additional cost to the Owner.
- P. "Replace": Remove existing and provide an equivalent product or material as specified.
- Q. "Extract (and Reinstall) ": Carefully disassemble, dismantle existing, save or store where directed by the Owner, in such a manner as to preserve the existing condition and reinstall as indicated on the drawings or as described in the specifications.
- R. Where any device or piece of equipment is referred to in the singular number, such reference shall be deemed to apply to as many devices as are required to complete the installation.

1.10 JOB CONDITIONS

- A. This contractor shall investigate all conditions affecting his work and shall provide such offsets, fittings, valves, sheet metal work, etc., as may be required to meet conditions at the building.
- B. The contractor shall verify all measurements at the building site and shall be responsible for the correctness of same before ordering materials or before starting work of any Section.
 - 1. Report to Architect, in writing, conditions which will prevent proper provision of this work.
 - 2. Beginning work of any Section without reporting unsuitable conditions to Architect constitutes acceptance of conditions by Contractor.
 - 3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.
- C. Piping and ductwork shall be concealed or run behind furring in finished spaces unless otherwise noted to be run exposed.
- D. Horizontal piping and ductwork not run below slabs on grade shall be run as close as possible to underside of roof or floor slab above and parallel to building lines. Maintain maximum headroom in all areas.
- E. Determine possible interference between trades before the work is fabricated or installed. The contractor must coordinate his work to insure that erection will proceed without such interference. Coordination is of paramount importance and no request for additional payment will be considered where such request is based upon interference between trades.
- F. Connections to Existing Work:
 - 1. Install new work and connect to existing work with minimum of interference to existing facilities.
 - 2. Temporary shutdowns of existing services:
 - 3. At no additional charges
 - a. At times not to interfere with normal operation of existing facilities.
 - b. Only with written consent of Owner.
 - 4. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
 - 5. Restore existing disturbed work to original condition.
- G. Removal, extraction and relocation of existing work.

1. The work includes demolition or removal of all construction indicated or specified. All materials resulting from demolition work, except as indicated or specified otherwise, shall become the property of the Contractor and shall be removed from the site. Rubbish and debris shall be removed from the site daily unless otherwise directed so as to not allow accumulation inside or outside the building. Materials that cannot be removed daily shall be stored in areas specified by the Owner.
2. Title to all materials and equipment to be demolished, excepting Owner salvage and historical items, is vested in the Contractor upon receipt of notice to proceed. The Owner will not be responsible for the condition, loss or damage to such property after notice to proceed.
3. The Owner reserves the "Right of First Refusal" on all material for salvage. Material for salvage shall be stored as approved by the Owner. Salvage materials shall be removed from the site before completion of the Contract. Material for salvage shall not be sold on the site.
4. Property of the Owner: Salvaged items remaining the property of the Owner shall be removed in a manner to prevent damage and packed or crated to protect the items from damage while in storage or during shipment and relocated by the contractor at no cost, to the Owners designated storage facility on the site. Containers shall be properly identified as to contents.
5. Damaged Items: Items damaged during removal or storage shall be repaired or replaced to match existing.
6. Disconnect, remove or relocate material, equipment, plumbing fixtures, piping and other work noted and required by removal or changes in existing conditions.
7. Where existing pipes, conduits and/or ducts which are to remain prevent installation of new work as indicated, relocate, or arrange for relocation, of existing pipes, conduits, and/or ducts.
8. Provide new material and equipment required for relocated equipment.
9. Plug or cap active piping or ductwork behind or below finish.
10. Do not leave long dead-end branches.
 - a. Cap or plug as close as possible to active line.
11. Remove unused piping, ductwork and equipment.
12. Dispose of unusable piping, ductwork and material.

1.11 CLEARANCE FROM ELECTRICAL EQUIPMENT

- A. Piping or ductwork:
 1. Prohibited, except as noted, in:
 - a. Electric rooms and closets.
 - b. Telephone rooms and closets.
 - c. Elevator machine rooms.
 - d. Electric switchboard room.
 2. Prohibited, except as noted, over or within 5 ft. of:
 - a. Transformers.
 - b. Substations.
 - c. Switchboards.
 - d. Motor control centers.
 - e. Standby power plant.
 - f. Bus ducts.
 - g. Electrical panels.

3. Drip pans under piping:
 - a. Only where unavoidable and approved.
 - b. 18 gauge galvanized steel.
 - 1) With bituminous paint coating.
 - c. Reinforced and supported.
 - d. Watertight.
 - e. With 1-1/4 inch drain outlet piped to floor drain or service sink.

1.12 TEMPORARY FACILITIES

- A. Temporary facilities are not included within this Section.

1.13 SPECIAL TOOLS

- A. Furnish to Owner at completion of work:
 1. One set of any special tools required to operate, adjust, dismantle or repair equipment furnished under any section of the Division.
 2. "Special tools": those not normally found in possession of mechanics or maintenance personnel.
 3. One pressure grease gun for each type of grease required.
 - a. With adapters to fit all lubricating fittings on equipment.
 - b. Include lubricant for lubricated plug valves.

1.14 PRODUCT DELIVERY, HANDING AND STORAGE

- A. Provide adequate and secure storage facilities for materials and equipment during the progress of the work.
- B. Contractor shall be responsible for the condition of all materials and equipment employed in the mechanical installation until final acceptance by the Owner. Protect same from any cause whatsoever.
- C. Where necessary, ship in crated sections of size to permit passing through available space.
- D. Ship equipment in original packages, to prevent damaging or entrance of foreign matter.
- E. Handle and ship in accordance with manufacturer's recommendations.
- F. Provide protective coverings during construction.
- G. Replace at no expense to Owner, equipment or material damaged during storage or handling, as directed by Engineer.
- H. Tag all items with weatherproof tag, identifying equipment by name and purchase order number.
- I. Include packing and shipping lists.
- J. Adhere to special requirements as specified in individual sections.

1.15 PROTECTION OF MATERIALS

- A. Protect from damage, water, dust, etc., material, equipment and apparatus provided under this Division, both in storage and installed, until Notice of Completion has been filed.
- B. Provide temporary storage facilities for materials and equipment.
- C. Material, equipment or apparatus damaged because of improper storage or protection will be rejected.
 1. Remove from site and provide new, duplicate, material, equipment, or apparatus in replacement of that rejected.

- D. Cover motors and other moving machinery to protect from dirt and water during construction. Rotate moving equipment, shafts, bearings, motors etc. to prevent corrosion and to circulate lubricants.
- E. Protect premises and work of other Divisions from damage arising out of installation of work of this Division.
 - 1. Contractor shall be responsible for the replacement of all damaged or defective work, materials or equipment. Do not install sensitive or delicate equipment until major construction work is completed.
 - 2. Remove replaced parts from premises.
- F. Make good any damage to the work caused by floods, storms, accidents, acts of God, acts of negligence, strikes, violence or theft up to time of final acceptance by the Owner.
- G. Do not leave any mechanical work in a hazardous condition, even temporarily.

1.16 REVIEW OF CONSTRUCTION

- A. Work may be reviewed at any time by representative of the Engineer.
- B. Advise Architect and Engineer that work is ready for review at following times:
 - 1. Prior to backfilling buried work.
 - 2. Prior to concealment of work in walls and above ceilings.
 - 3. When all requirements of Contract have been completed.
- C. Neither backfill nor conceal work without Engineer's consent.
- D. Maintain on job a set of Specifications and Drawings for use by Engineer's representatives.

1.17 SCHEDULE OF WORK

- A. Arrange work to conform to schedule of construction established or required to comply with Contract Documents.
- B. In scheduling, anticipate means of installing equipment through available openings in structure.
- C. Confirm in writing to Architect and Engineer, within 30 days of signing of contract, anticipated number of days required to perform test, balance, and acceptance testing of mechanical systems.
 - 1. This phase must occur after completion of mechanical systems, including all control calibration and adjustment, and requires substantial completion of the building, including closure, ceilings, lighting, partitioning, etc.
 - 2. Submit for approval at this time, names and qualifications of test and balancing agencies to be used.
- D. Arrange with Owner schedule for work in each area.
- E. Unless otherwise directed by Owner, perform work during normal working hours.
- F. Work delays:
 - 1. In case noisy work interferes with Owner's operations, Owner may require work to be stopped and performed at some other time, or after normal working hours.

1.18 ACCESS TO MECHANICAL WORK

- A. Access doors in walls and ceilings.
- B. Access Units Fire-Resistance Ratings: Where fire-resistance rating is indicated for construction penetrated by access units, provide UL listed-and-labeled units, except for units which are smaller than minimum size requiring ratings as recognized by governing authority.

- C. Product Data, Access Units: Submit manufacturer's technical data and installation instructions for each type of access door assembly, including setting drawings, templates, instructions and directions for installation of anchorage devices.
- D. Furnish to the general contractor all access doors necessary for access through inaccessible wall or ceiling construction, for installation by the general contractor. Information on the size and location of the subject access doors is to be communicated in writing to the general contractors during the bidding period.

1.19 CONCRETE FOR MECHANICAL WORK

- A. Concrete for Mechanical Work
 - 1. Basins and curbs for mechanical equipment.
 - 2. Mechanical equipment foundations and housekeeping pads.
 - 3. Inertia bases for isolation of mechanical work.
 - 4. Rough grouting in and around mechanical work.
 - 5. Patching concrete cut to accommodate mechanical work.
- B. Quality control testing for concrete is required as work of this section.
- C. Concrete Work Codes and Standards:
 - 1. Comply with governing regulations and, where not otherwise indicated, comply with the following industry standards; whichever is the most stringent in its application to work in each instance.
 - a. ACI 301: "Specifications for Structural Concrete for Buildings"
 - b. ACI 311: "Recommended Practice for Concrete Inspection"
 - c. ACI 318: "Building Code Requirements for Reinforced Concrete"
 - d. ACI 347R: "Recommended Practice for Concrete Form work"
 - e. ACI 304R: "Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete"
 - f. Concrete Reinforcing Steel Institute's, "Manual of Standard Practice"
- D. Submittals: Shop Drawings, Mechanical Concrete Work: Submit shop drawings for structural type concrete work, showing dimensions of formed shapes of concrete; bending, placement, sizes and spacing of reinforcing steel; location of anchors, isolation units, hangers and similar devices to be integrated with concrete work; and piping penetrations, access openings, inlets and other accessories and work to be accommodated by concrete work.
- E. Laboratory Test Reports, Mechanical Concrete Work: Submit laboratory test reports for concrete work materials, and for tested samples of placed concrete (where required as work of this section).

1.20 NOISE REDUCTION

- A. Cooperate in reducing objectionable noise or vibration caused by mechanical systems.
 - 1. To extent of adjustments to specified and installed equipment and appurtenances.
- B. Correct noise problems caused by failure to install work in accordance with Contract Documents.
 - 1. Include labor and materials required as result of such failure.

1.21 CUTTING AND PATCHING

- A. Provide all carpentry, cutting and patching required for proper installation of material and equipment specified.
- B. Do not cut or drill structural members without consent of Architect.

1.22 COORDINATION DRAWINGS**A. Layout Shop Drawings Required:**

1. Prepare layout shop drawings for all areas; minimum 3/8 inch scale.
2. Individual coordinated trade layout drawings are to be prepared for all areas.
3. General Contractor is to assure that each trade has coordinated work with other trades, prior to submittal where submittal is required.
 - a. Include stamp on each submittal indicating that layout shop drawing has been coordinated.
4. No layout shop drawing will be reviewed without stamped and signed coordinated assurance by General Contractor.
5. All changes shall be clearly marked on each submitted layout drawing.
6. Drawings shall show work of all trades including but not limited to'
 - a. Ductwork.
 - b. Piping: All Trades.
 - c. Mechanical Equipment.
 - d. Electrical Equipment.
 - e. Main Electrical conduits and bus ducts.
 - f. Equipment supports and suspension devices.
 - g. Structural and architectural constraints.
 - h. Show location of:
 - 1) Valves
 - 2) Piping specialties
 - 3) Dampers
 - 4) Access Doors
 - 5) Control and electrical panels
 - 6) Disconnect switches
7. Drawings shall indicate coordination with work in other Divisions that must be incorporated in mechanical spaces, including, but not limited to:
 - a. Elevator equipment.
 - b. Cable trays not furnished under Division 16.
 - c. Computer equipment.
8. Submission of drawings:
 - a. Prepare reproducible drawings.
 - b. Submit to other trades for review of space allocated to all trades.
 - c. Revise drawings to compensate for requirements of existing conditions and conditions created by other trades.
 - d. Review revisions and other trades.
 - e. Submit one reproducible and one blue-line print to Engineer for review.
9. Final prepared drawings shall show that other trades affected have made reviews and signed, by each trade, at completions of coordination.
 - a. General Contractor
 - b. Include stamp on each submittal indicating that layout shop drawing has been coordinated.
10. No layout shop drawing will be reviewed without stamped and signed coordination assurance by General Contractor.

B. Shop Drawings:

1. Layout drawings of mechanical equipment rooms and penthouses showing all related equipment and equipment clearances required by other trades.
2. Layout drawings of areas in which it may be necessary to deviate substantially from layout shown on the drawings. Minor transitions in ductwork, if required due to job conditions, need not be submitted as long as the duct area is maintained. Show major relocation of ductwork and major changes in size of ducts. Coordinate shop drawings with all trades prior to ductwork fabrication.
3. Details of intermediate structural steel members required to span main structural steel for the support of ductwork.
4. Method of attachment of duct hangers to building construction.
5. Duct material, gage, type of joints and duct reinforcing for each size range, including sketches or SMACNA plate numbers for joints, method of fabrication and reinforcing.

1.23 GUARANTEE

- A. Furnish guarantee covering all work in accordance with general requirements of the contract for minimum period of one year. This guarantee shall exist for a period of one (1) year from the date of final acceptance of the work and shall apply to defects in materials and to defective workmanship of any kind.
- B. For factory-assembled equipment and devices on which the manufacturers furnish standard published guarantees as regular trade practice, obtain such guarantees and replace any such equipment that proves defective during the life of these guarantees.
- C. Guarantee all work for which materials are furnished, fabricated or field erected by the contractor, all factory-assembled equipment for which no specific manufacturer's guarantee is furnished, and all work in connection with installing manufacturer's guarantee is furnished, and all work in connection with installing manufacturer's guaranteed equipment.
- D. In the event of failure of any work, equipment or device during the life of the guarantee, repair or replace the equipment or defective work. Remove, replace or restore, at no cost to the Owner, any part of the structure or building which may be damaged either as the direct result of the defective work or in the course of the contractor's making replacement of the defective work or materials. Work shall be done at a time and in a manner as to cause no undue inconvenience to the Owner. Provide new materials, equipment, apparatus and labor to replace that determined by Engineer to be defective or faulty.
- E. This guarantee also applies to services including Instructions, Adjusting, Testing, Noise, Balancing, etc.
- F. Additional equipment and material guarantees and warranties may be indicated in other sections. In all cases, the more stringent guarantee or warranty shall be provided.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT QUALITY

- A. Material and equipment furnished under this Division of specification shall be new. Defective or inferior materials must be replaced by contractor at no cost to Owner regardless of the stage of construction. Inferior material shall be defined as material or equipment of a quality or performance less than that specified as determined by the Owner's Representative.
- B. Provide each item of equipment with manufacturer's identification tag which is readily accessible and clearly shows model and size.

2.02 ACCESS TO MECHANICAL WORK

A. Access Doors:

1. General: Where walls and ceilings must be penetrated for access to mechanical work, access doors shall be provided. Furnish adequate size for intended and necessary access. Furnish doors with UL Fire Rating to match wall or ceiling construction. Furnish manufacturer's complete units, of type recommended for application in indicated substrate construction, in each case, complete with anchorages and hardware.

B. Access Door Construction: Refer to Section 083100 – ACCESS DOORS AND PANELS**PART 3 - EXECUTION****3.01 FIELD QUALITY CONTROL****A. Tests:**

1. Perform as specified in individual sections, and as required by authorities having jurisdiction.
2. Duration as noted.

B. Provide required labor, material, equipment, and connections.**C. Furnish written report and certification those tests have been satisfactorily completed.****D. Repair or replace defective work, as directed.****E. Pay for restoring or replacing damaged work due to tests as directed.****F. Pay for restoring or replacing damaged work of others, due to tests, as directed.****3.02 ACCESS TO MECHANICAL WORK****A. Coordinate installation and placement of access doors and panels with contractor for general construction.****B. Remove or replace panels or frames that are warped, bowed, or otherwise damaged.****END OF SECTION 230000**

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**SECTION 230002
MECHANICAL AND ELECTRICAL COORDINATION**

PART 1 - GENERAL

1.01 WORK INCLUDED

- A. Work Included in This Section: Materials, equipment, fabrication, installation, and tests in conformity with applicable codes and authorities having jurisdiction for the following:
 - 1. Motors.
 - 2. Factory-wired equipment (FWE).
 - 3. Factory-wired control panels (FWCP).
 - 4. Motor controllers where provided as part of mechanical equipment.
 - 5. Motor controllers where supplied under Division 23 - Mechanical Work.
 - 6. Disconnects and safety switches for mechanical equipment.
 - 7. Fuses for equipment provided, and starters and disconnect switches.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Division 23 - HVAC Instrumentation and Controls, Motors.
- B. Installation and Power Wiring of Motor Controllers.

1.03 REFERENCE STANDARDS

- A. Published specifications standards, tests, or recommended methods of trade, industry or governmental organization as apply to work in this section where cited below:
 - 1. ANSI - American National Standards Institute.
 - 2. NEMA - National Electrical Manufacturer's Association.
 - 3. IEEE - Institute of Electrical and Electronic Engineers.

1.04 QUALITY ASSURANCE

- A. All equipment and accessories to be the product of a manufacturer regularly engaged in its manufacture.
- B. Supply all equipment and accessories new and free from defects.
- C. Supply all equipment and accessories in compliance with the applicable standards listed in Article 1.03 of this Section and with all applicable National, State and local codes.
- D. All items of a given-type shall be the products of the same manufacturer.

1.05 DIVISION OF WORK

- A. This section delineates the work required to be performed by Contractors under Division 23 and Division 26.

1.06 WORK REQUIRED UNDER DIVISION 23

- A. Furnish motors, manual and combination starters, pushbutton devices, contactors, disconnect switches, electric thermostats, low voltage transformers, Emergency Break Glass Stations and other electrical devices required for equipment furnished.
- B. Install all items in piping and ductwork such as control valves, aquastats, ductstats, etc.
- C. All external wiring of equipment, all control wiring, external wiring of control circuits of magnetic starters, interlocking wiring, boiler wiring, Emergency Break Glass Stations, and mounting of control devices, etc., shall be included under Division 23. All external wiring shall be in conduit. (Unless specifically shown to be provided by the Electrical Contractor)

- D. Control wiring shall be defined as wiring required for the complete operation of all temperature control and mechanical equipment automation control device components. Power wiring for control panels, I/O Modules, unitary controllers, mechanical equipment control panels, etc. shall be considered as control wiring. The wiring required, regardless of voltage, to provide power to all control components shall be included under Division 23 unless specifically shown to be provided by the Electrical Contractor.
- E. The Electrical Contractor, under Division 26, shall furnish and install all power wiring and conduit to junction box, to disconnect switch on unit, to motor starters and contactors, and between motor starters and contactors to motor or other load. Electrical Contractor shall be responsible for proper direction of rotation for all three phase equipment. The Electrical Contractor shall mount all starters, disconnects.
- F. Wiring required under Division 23 shall comply with the specifications as described in Division 26.
- G. The Plumbing Contractor, under Division 22, shall provide water and natural gas services to within two (2) feet of HVAC equipment requiring same and terminating with shut-off valves. The HVAC Contractor, under Division 23, shall make final connections to equipment.
- H. Provide disconnect switches or safety switches for equipment. (Unless specifically shown to be provided by the Electrical Contractor, starters and disconnects shown on the electrical drawings are for installation and do not require the Electrical Contractor to furnish units)

1.07 SUBMITTALS

- A. Shop Drawings: Complete wiring diagrams of all power and control connections (standard diagrams will not be accepted). Deliver 2 copies of approved wiring diagrams to the Electric Contractor for installation of wiring and connections required under the Electric Contract.
- B. Product Data for Motor Controllers and Disconnect Switches: Manufacturer's catalog sheets, specifications and installation instructions. Submit enclosure type coordinated for service and location. Submit simultaneously with product data required for motors. Identify each controller for use with corresponding motor. Submit shop drawings and product data in accordance with project requirements.
- C. All warranties shall be delivered as part of the close-out submission.
- D. A receipt shall be delivered as part of the close-out submission that states all required spare parts have been delivered to the owner. This receipt must be signed and dated by the owner.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Motor Controllers and Disconnects
 - 1. Square D
 - 2. Allen-Bradley
 - 3. General Electric
 - 4. Cutler-Hammer

2.02 MOTOR CONTROLLERS

- A. General: All starters shall be correctly sized to motor connected thereto. Provide one (1) additional auxiliary contact over and above that normally furnished, at least two (2) required. Provide overload heaters for each phase. Coordinate starters and controllers with the temperature control Contractor and sequence of operations.

- B. Minimum Size: The minimum allowable size of single or three phase magnetic motor controller is NEMA size 0.
- C. Enclosures: Unless otherwise indicated furnish NEMA 1 enclosures, except where installed outdoors furnish NEMA 3R enclosures.
- D. Control Power: Furnish control power transformer (maximum control voltage 120 volts) mounted within each magnetic motor controller enclosure.
- E. Local Control Devices: Where indicated, furnish standard duty push buttons or 3-position hand-off-auto selector switch mounted in the controller enclosure.
- F. Pilot Lights: Furnish pilot lights of the neon lamp type mounted in the controller enclosure, green for running, red for not running.

2.03 MOTOR CONTROLLER TYPES:

- A. Type A (Full Voltage, Manual, Non-Magnetic):
 - 1. Allen-Bradley Co. Bulletin 609 (or Bulletin 600 - single phase, 1 HP or less only).
 - 2. General Electric Co. CR-1062 (or CR-101 - single phase, 1 HP or less only).
 - 3. Cutler-Hammer. B100 (or MS - single phase, 1 HP or less only).
- B. Type A2 (2 Speed, 2 Winding, Full Voltage, Manual, Non-Magnetic):
 - 1. Allen-Bradley Co. Bulletin 609TS (or Bulletin 600 - single phase, 1 HP or less only).
 - 2. General Electric Co. CR-1062 (or CR-101 - single phase, 1 HP or less only).
 - 3. Square D Co. Class 2512, Type M (or Class 2512, Type F - single phase, 1 HP or less only).
- C. Type B (Full Voltage Magnetic):
 - 1. Allen-Bradley Co. Bulletin 709.
 - 2. General Electric Co. CR-206.
 - 3. Square D Co. Class 8536.
 - 4. Cutler-Hammer. ECN05.
- D. Type B-COM (Combination Full Voltage Magnetic/Safety Switch):
 - 1. Allen-Bradley Co. Bulletin 712.
 - 2. General Electric Co. CR-208.
 - 3. Square D Co. Class 8538.
 - 4. Cutler-Hammer. ECN16.
- E. Type B2 (2 Speed, 2 Winding, Full Voltage, Magnetic):
 - 1. Allen-Bradley Co. Bulletin 715.
 - 2. General Electric Co. CR209.
 - 3. Square D Co. Class 8810.
 - 4. Cutler-Hammer. ECN33.
- F. Type C (Automatic, Reduced Voltage, Magnetic):
 - 1. Allen-Bradley Co. Bulletin 746.
 - 2. General Electric Co. CR-231.
 - 3. Square D Co. Class 8606.
 - 4. Cutler-Hammer. ECA42.
- G. Type C-COM (Combination Automatic, Reduced Voltage, Magnetic/ Safety Switch):

1. Allen-Bradley Co. Bulletin 746C.
 2. Square D Co. Class 8606.
 3. Cutler-Hammer. ECA43.
- H. Type D (Part Winding, Magnetic):
1. Allen-Bradley Co. Bulletin 736.
 2. General Electric Co. CR-230.
 3. Square D Co. Class 8640.
 4. Cutler-Hammer. ECA45.

2.04 REMOTE PUSH BUTTON STATIONS

- A. Start-Stop with pilot light in NEMA 1 enclosure unless otherwise indicated.
1. Allen-Bradley Co. Bulletin 800S.
 2. General Electric Co. CR-2943.
 3. Square D Co. Class 9001.
 4. Cutler-Hammer. Class 10250.

2.05 SAFETY SWITCHES

- A. General Electric Co. Type TH; Square D Co. Heavy Duty Series; Cutler-Hammer HD Series; with the following:
1. Fused switches equipped with fuseholders to accept only the fuses specified in Section 16181 (U.L. Class RK-1, RK-5, L).
 2. NEMA 1 enclosure unless otherwise indicated on drawing or required. 3R for devices installed outdoors.
 3. Switch rated 240V for 120V, 208V, 240V, circuits; 600 V for 277V, 480V circuits.
 4. Switch rated 600V for 277V, 480V circuits.
 5. Solid neutral bus when neutral or grounding conductor is included with circuit.
 6. Current rating and number of poles as indicated on drawings.

2.06 NAMEPLATES

- A. Phenolic Type: Standard phenolic nameplates with 3/8" minimum size lettering engraved thereon.
- B. Embossed Aluminum: Standard stamped or embossed aluminum tags: Tech Products, Inc., Seton Name Plate Corp.

2.07 EMERGENCY PUSHBUTTON OPERATOR STATION

- A. Acceptable Manufacturer: Square D or equal.
- B. Switch Style: Class 9001, NEMA 4 rated emergency mushroom head pushbutton.
- C. Voltage: 120VAC, 60Hz as required.
- D. Contacts: 20A, 2-NO/2-NC contact.
- E. Operation: Manual.
- F. Normal position: Operator out.
- G. Activated position: Operator in.
- H. Reset: Manual, turn to release.
- I. Enclosure: NEMA 4.

2.08 CUSTOM LEGEND PLATE

- A. "EMERGENCY BOILER SHUTOFF"

PART 3 - EXECUTION

3.01 GENERAL

- A. Equipment shall be connected in a neat and skillful manner. Equipment deliver with terminal boxes that are inadequate shall be equipped with special boxes that suit the conditions by the Mechanical Contractor furnishing the equipment.
- B. In general, rigid conduit or tubing shall be used, but equipment that requires movement or that would transmit vibration to conduit shall be wired with flexible (liquid tight) steel conduit not over 18" long.
- C. All equipment shall be grounded with a green-covered ground wire run inside the conduit and connected to equipment frame on one end and to grounding system on the other end.
- D. All electrical work required in the Mechanical Contract shall conform to the applicable requirements of Division 26 of these Specifications.
- E. The Heating, Ventilating, and Air Conditioning Contractor shall assign all Electrical Work required under his contract to the approved Automatic Temperature Control Contractor, who shall perform this work with qualified electricians employed by that Contractor.
- F. The Mechanical Contractors shall cooperate with the Contractor for Electrical Work in making all necessary tests and in receiving, storing, and setting all motor-driven equipment, electrical devices, and controls furnished and/or installed under these contracts.
- G. Install heaters correlated with full load current of motors provided.
- H. Set overload devices to suit motors provided.

3.02 INSTALLATION

- A. Control Wiring:
 - 1. Provide control wiring and connections.
 - 2. Where control circuit interlocking is required between individually mounted motor controllers, provide a single pole on-off switch in a threaded type box mounted adjacent to motor safety switches which are remote from the control transformer (to enable interlock circuit to be opened when the motor safety switch is opened).
- B. Nameplates: Rivet or bolt the nameplate on the cover of NEMA 1 enclosures. Rivet or bolt and gasket the nameplate on cover of NEMA 3R or NEMA 12 enclosures. Provide phenolic or embossed aluminum nameplates as follows:
 - 1. On each remote control station, indicating motor controlled.
 - 2. On each interlock circuit switch, indicating purpose of switch.
- C. Emergency Pushbutton Operator Station: Wire all switches in series with boiler control branch circuits.

3.03 TYPES OF MOTOR CONTROLLERS REQUIRED FOR SINGLE SPEED MOTORS (SYSTEMS UNDER 250 VOLTS)

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A.
- B. Single Phase Motors Less than 1/2 HP - Automatically Operated: Type A.
- C. Single Phase Motors 1/2 to 5 HP - Automatically Operated: Type B.

- D. Three Phase Squirrel Cage Motors Less than 7-1/2 HP: Type B (B-COM when indicated on drawings).
- E. Three Phase Squirrel Cage Motors 7-1/2 HP and Larger: Type C (C-COM when indicated on drawings).
- F. Three Phase Hermetically Sealed Compressor Motors Less than 7-1/2 HP: Type B.
- G. Three Phase Hermetically Sealed Compressor Motors 7-1/2 HP and Larger: Type D.

3.04 TYPES OF MOTOR CONTROLLERS REQUIRED FOR SINGLE SPEED MOTORS (277/480 VOLT SYSTEM)

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A.
- B. Single Phase Motors Less than 1 HP - Automatically Operated: Type A.
- C. Single Phase Motors 1 to 5 HP - Automatically Operated: Type B.
- D. Three Phase Squirrel Cage Motors Less than 15 HP: Type B (B-COM when indicated on drawings).
- E. Three Phase Squirrel Cage Motors 15 HP and Larger: Type C (C-COM when indicated on drawings).
- F. Three Phase Hermetically Sealed Compressor Motors Less than 15 HP: Type B.
- G. Three Phase Hermetically Sealed Compressor Motors 15 HP and Larger: Type D.

3.05 TYPES OF MOTOR CONTROLLERS REQUIRED FOR 2 SPEED MOTORS (SYSTEMS UNDER 250 VOLTS)

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A2.
- B. Single Phase Motors Less than 1/2 HP - Automatically Operated: Type A2.
- C. Single Phase Motors 1/2 to 5 HP - Automatically Operated: Type B2.
- D. Three Phase Squirrel Cage Motors Less than 7-1/2 HP: Type B2.

3.06 TYPES OF MOTOR CONTROLLERS REQUIRED FOR 2 SPEED MOTORS (277/480 VOLT SYSTEM)

- A. Single Phase Motors Less than 5 HP - Manually Operated: Type A2.
- B. Single Phase Motors Less than 1 HP - Automatically Operated: Type A2.
- C. Single Phase Motors 1 to 5 HP - Automatically Operated: Type B2.
- D. Three Phase Squirrel Cage Motors Less than 15 HP: Type B2.

3.07 DISCONNECTS

- A. Motor Controllers: Provide safety switch for all motor controllers. Provide combination type starter-disconnect unless otherwise noted on drawings.
- B. Motors: Provide a disconnect switch for all motors. Provide a separate safety switch for motors which are not within sight of the starter.
- C. Provide safety switches for all factory packaged equipment.
- D. Provide NEMA 3R safety switch for all rooftop and outdoor equipment.

- E. Provide unit mounted disconnect switches for all equipment such as unit heaters, fans, unit ventilators, incremental units, etc

3.08 EMERGENCY PUSHBUTTON OPERATOR STATION

- A. Provide Emergency Pushbutton Operator Station at each boiler room exit to de-energize the primary control circuit and to close the main fuel valves to stop the flow of fuel to the burner during an emergency.
- B. Review plans for locations.
- C. Provide all conduit and wiring for interlock of each boiler.

END OF SECTION 230002

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SECTION 230130.51
HVAC AIR-DISTRIBUTION SYSTEM CLEANING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Cleaning of HVAC duct system, equipment, and related components.

1.02 RELATED REQUIREMENTS

- A. Section 019113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- B. Section 230800 - Commissioning of HVAC.

1.03 DEFINITIONS

- A. HVAC System: For purposes of this section, the surfaces to be cleaned include all interior surfaces of the heating, air-conditioning and ventilation system from the points where the air enters the system to the points where the air is discharged from the system, including the inside of air distribution equipment, coils, and condensate drain pans; see NADCA ACR for more details.
 - 1. Exhaust-only system is not required to be cleaned.

1.04 REFERENCE STANDARDS

- A. NADCA ACR - The NADCA Standard for Assessment, Cleaning, and Restoration of HVAC Systems; 2025.
- B. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.
- C. UL 181A - Closure Systems for Use with Rigid Air Ducts; Current Edition, Including All Revisions.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Manufacturer's data sheets on each product to be used.
- C. Qualifications Statement: Submit qualifications of proposed cleaning contractor for approval.
- D. Project Cleanliness Evaluation and Cleaning Plan, as specified.
- E. Material Safety Data Sheets (MSDS): For all chemical products proposed to be used in the cleaning process; submit directly to Owner.
- F. Project Closeout Report: Include field quality control reports, evidence of satisfactory cleaning, and documentation of items needing further repair.

1.06 QUALITY ASSURANCE

- A. Cleaning Contractor Qualifications: Company specializing in the cleaning and restoration of HVAC systems as specified in this section.
 - 1. Certified by one of the following:
 - a. NADCA, National Air Duct Cleaners Association: www.nadca.com.
 - b. Nationally recognized certification program and organization dedicated to the cleaning of HVAC systems.
 - 2. Having minimum of three years documented experience.

- 3. Employing for this project a supervisor certified by same organization that certified the cleaning contractor.
- B. Testing and Inspection Agency Qualifications: Experienced in inspection and testing using methods defined in NADCA ACR.

PART 2 PRODUCTS

2.01 TOOLS AND EQUIPMENT

- A. Vacuum Devices and Other Tools: Exceptionally clean, in good working order, and sealed when brought into the facility.
- B. Vacuum Devices That Exhaust Air Inside Building, Including Hand-Held and Wet Vacuums: Equipped with HEPA filtration with 99.97 percent collection efficiency for minimum 0.3-micron size particles and DOP test number.
- C. Vacuum Devices That Exhaust Air Outside Building, Including Truck- and Trailer-Mounted Types: Equipped with particulate collection including adequate filtration to contain debris removed from the HVAC system; exhausted in manner that prevents contaminant re-entry to building; compliant with applicable regulations as to outdoor environmental contamination.

2.02 REPLACEMENT PRODUCTS

- A. Fibrous Glass Insulation: Provide material complying with UL 181 equivalent to existing material in quality and thickness.

PART 3 EXECUTION

3.01 SCOPE

- A. Systems included in the scope of this project.
 - 1. All existing HVAC systems modified or retrofitted in this project.
 - a. For existing systems, cleaning of entire distribution system is required.

3.02 PROJECT CONDITIONS

- A. Comply with applicable federal, state, and local requirements.
- B. Perform cleaning, inspection, and remediation in accordance with the recommendations of NADCA "Assessment, Cleaning and Restoration of HVAC Systems" (ACR) and as specified herein.
- C. Where NADCA ACR uses the terms "recommended", "highly recommended", or "ideally" in regard to a certain procedure or activity, do that unless it is clearly inapplicable to the project.
- D. Take precautions to prevent introduction of additional hazards into occupied spaces.
- E. Obtain Owner's approval of proposed temporary locations for large equipment.
- F. Designate a decontamination area and obtain Owner's approval.
- G. When portions of the facility are to remain occupied or in operation during cleaning activities, provide adequate controls or containment to prevent access to spaces being cleaned by unauthorized persons and provide detailed instructions to Owner as to these controls or containment.
- H. If unforeseen mold or other biological contamination is encountered, notify Architect immediately, identifying areas affected and extent and type of contamination.

3.03 EXAMINATION

- A. Prior to the commencement of any cleaning work, prepare and submit to Architect a project evaluation and plan for this project, including considerations recommended in NADCA ACR.
- B. Inspect the system as required to determine appropriate methods, tools, equipment, and protection.
- C. Start of cleaning work constitutes acceptance of existing conditions.
- D. When concealed spaces are later made accessible, examine and document interior conditions prior to beginning cleaning.
- E. Document all instances of mold growth, rodent droppings, other biological hazards, and damaged system components.

3.04 PREPARATION

- A. When cleaning work might adversely affect life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with authorities having jurisdiction.
- B. Ensure that electrical components that might be adversely affected by cleaning are de-energized, locked out, and protected prior to beginning work.
- C. Air-Volume Control Devices: Mark the original position of dampers and other air-directional mechanical devices inside the HVAC system prior to starting cleaning.
- D. Access to Concealed Spaces: Use existing service openings and make additional service openings as required to accomplish cleaning and inspection.
 - 1. Do not cut openings in non-HVAC components without obtaining the prior approval of Owner.
 - 2. Make new openings in HVAC components in accordance with NADCA Standard 05; do not compromise the structural integrity of the system.
 - 3. Do not cut service openings into flexible duct; disconnect at ends for cleaning and inspection.
- E. Ceiling Tile: Lay-in ceiling tile may be removed to gain access to HVAC systems during the cleaning process; protect tile from damage and reinstall upon completion; replace damaged tile.

3.05 CLEANING

- A. Use any cleaning method recommended by NADCA ACR unless otherwise specified; do not use methods prohibited by NADCA ACR, or that will damage HVAC components or other work, or that will significantly alter the integrity of the system.
- B. Obtain Owner's approval before using wet cleaning methods; ensure that drainage is adequate before beginning.
- C. Ducts: Mechanically clean all portions of ducts.
- D. Hoses, Cables, and Extension Rods: Clean using suitable sanitary damp wipes at the time they are being removed or withdrawn from their normal position.
- E. Registers, Diffusers, and Grilles: When removing, take care to prevent containment exposure due to accumulated debris.
- F. Coils: Follow NADCA ACR completely including measuring static pressure drop before and after cleaning; do not remove refrigeration coils from system to clean; report coils that are permanently impacted.

- G. Fibrous Glass Material: Use HEPA vacuuming equipment, under constant negative pressure, do not permit to get wet, and do not damage surfaces; replace material damaged by cleaning operations.
- H. Existing Damaged Fibrous Glass Material: Report to Architect all evidence of damage, deterioration, delaminating, friable material, mold or fungus growth, or moisture that cannot be remedied by cleaning or resurfacing with an acceptable insulation repair coating.
 - 1. Material with active fungal growth is considered unremediable.
 - 2. Remove unremediable material and clean underlying surfaces.
 - 3. Replacement of unremediable material is not covered by this specification.
- I. Collect debris removed during cleaning; ensure that debris is not dispersed outside the HVAC system during the cleaning process.
- J. Store contaminated tools and equipment in polyethylene bags until cleaned in the designated decontamination area.

3.06 REPAIR

- A. Repair openings cut in the ventilation system so that they do not significantly alter the airflow or adversely impact the facility's indoor air quality.
- B. At insulated ducts and components, accomplish repairs in such a manner as to achieve the equivalent thermal value.
- C. Reseal new openings in accordance with NADCA Standard 05.
- D. Reseal rigid fiber glass duct systems using closure techniques that comply with UL 181 or UL 181A.
- E. When new openings are intended to be capable of being re-opened in the future, clearly mark them and report their locations to Owner in project report documents.

3.07 FIELD QUALITY CONTROL

- A. Ensure that the following field quality control activities are completed prior to application of any treatments or coatings and prior to returning HVAC system to normal operation.
- B. Visually inspect all portions of the cleaned components; if not visibly clean as defined in NADCA ACR, re-clean and reinspect.
- C. Coils: Cleaning must restore the coil pressure drop to within 10 percent of the coil's original installed pressure drop; if original pressure drop is not known, coil will be considered clean if free of foreign matter and chemical residue based on visual inspection.
- D. Notify Architect when cleaned components are ready for inspection.
- E. When directed, re-clean components until they pass.
- F. Contractor shall bear the costs of retesting due to inadequate cleaning.
- G. Submit evidence that all portions of the system required to be cleaned have been cleaned satisfactorily.

3.08 ADJUSTING

- A. After satisfactory completion of field quality control activities, restore adjustable devices to original settings, including, but not limited to, dampers, air directional devices, valves, fuses, and circuit breakers.

3.09 WASTE MANAGEMENT

- A. Double-bag waste and debris in 6 mil, 0.006 inch thick polyethylene plastic bags.

- B. Dispose of debris off-site in accordance with applicable federal, state and local requirements.

END OF SECTION 230130.51

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**SECTION 230513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. General construction and requirements.
- B. Applications.
- C. Single phase electric motors.
- D. Three phase electric motors.
- E. Electronically Commutated Motors (ECM).

1.02 RELATED REQUIREMENTS

- A. Section 262913 - Enclosed Controllers.

1.03 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015, with Errata (2026).
- B. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; 2017.
- C. NEMA MG 00001 - Motors and Generators; 2024.
- D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
- D. Operation Data: Include instructions for safe operating procedures.
- E. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.05 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.07 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for motors larger than 20 horsepower.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Baldor Electric Company/ABB Group: www.baldor.com/#sle.
- B. Leeson Electric Corporation: www.leeson.com/#sle.
- C. Regal-Beloit Corporation (Century): www.centuryelectricmotor.com/#sle.
- D. Substitutions: See Section 016000 - Product Requirements.

2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Construction:
 - 1. Open drip-proof type except where specifically noted otherwise.
 - 2. Design for continuous operation in 104 degrees F environment.
 - 3. Design for temperature rise in accordance with NEMA MG 00001 limits for insulation class, service factor, and motor enclosure type.
- B. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- C. Wiring Terminations:
 - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
 - 2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.03 APPLICATIONS

- A. Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not comply with these specifications.
- B. Single phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type.
- C. Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, and dust collection systems: Totally enclosed type.

2.04 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.05 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- B. Starting Current: Six times full load current.

- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Comply with NEMA MG 00001 for Design B motors.
- E. Insulation System: NEMA Class B or better.
- F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 262913.
- I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- J. Sound Power Levels: To NEMA MG 00001.
- K. Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- L. Nominal Efficiency: As indicated at full load and rated voltage when tested in accordance with IEEE 112.
- M. Nominal Power Factor: As indicated at full load and rated voltage when tested in accordance with IEEE 112.

2.06 ELECTRONICALLY COMMUTATED MOTORS (ECM)

- A. Applications:
 - 1. Commercial:
 - a. Roof Top Unit:
 - 1) Operating Mode: Constant speed.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the roof top unit and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
 - b. Hydronic Fan Coil Unit:
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the fan coil unit and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
 - 4) Options: User-interface.
 - 5) RPM: 300 through 1250.
 - c. Power Roof Ventilator (PRV):
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the PRV and/or specified sequence of operation.

- 3) Shaft Extension: Single.
- d. Energy Recovery Ventilator:
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the energy recovery ventilator and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
- e. Hydronic Pump:
 - 1) Operating Mode: Constant speed.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the hydronic pump and/or specified sequence of operation.
 - 3) Flange Configuration: "C".

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Check line voltage and phase and ensure agreement with nameplate.

END OF SECTION 230513

**SECTION 230517
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe sleeves.
- B. Pipe-sleeve seals.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 230523 - General-Duty Valves for HVAC Piping.
- C. Section 230553 - Identification for HVAC Piping and Equipment: Piping identification.
- D. Section 230719 - HVAC Piping Insulation.

1.03 REFERENCE STANDARDS

- A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2016.
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2024.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

1.07 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a one year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.01 PIPE SLEEVES

- A. Vertical Piping:
 - 1. Sleeve Length: 1 inch above finished floor.
 - 2. Provide sealant for watertight joint.
 - 3. Blocked Out Floor Openings: Provide 1-1/2 inch angle set in silicon adhesive around opening.
 - 4. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- B. Sheet Metal: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.

- C. Pipe Passing Through Mechanical Room Floors above Basement:
 - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 - 2. Connect sleeve with floor plate except in mechanical rooms.
- D. Clearances:
 - 1. Provide allowance for insulated piping.
 - 2. Wall, Floor, Partitions, and Beam Flanges: 1 inch greater than external pipe diameter.
 - 3. All Rated Openings: Caulked tight with fire stopping material in compliance with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.

2.02 PIPE-SLEEVE SEALS

- A. Modular Mechanical Sleeve-Seal:
 - 1. Elastomer-based interlocking links continuously fill annular space between pipe and wall-sleeve, wall or casing opening.
 - 2. Watertight seal between pipe and wall-sleeve, wall or casing opening.
 - 3. Size and select seal component materials in accordance with service requirements.
 - 4. Glass-reinforced plastic pressure end plates.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- E. Structural Considerations:
 - 1. Do not penetrate building structural members unless indicated.
- F. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
 - 1. Aboveground Piping:
 - a. Pack solid using mineral fiber in compliance with ASTM C592.
 - b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
 - 2. All Rated Openings: Caulk tight with fire stopping material in compliance with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.

3. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.
- G. Manufactured Sleeve-Seal Systems:
1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 3. Locate piping in center of sleeve or penetration.
 4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
 5. Tighten bolting for a water-tight seal.
 6. Install in accordance with manufacturer's recommendations.
- H. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.03 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

END OF SECTION 230517

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**SECTION 230519
METERS AND GAUGES FOR HVAC PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pressure gauges and pressure gauge taps.
- B. Thermometers and thermometer wells.
- C. Static pressure gauges.
- D. Filter gauges.

1.02 RELATED REQUIREMENTS

- A. Section 232113 - Hydronic Piping.

1.03 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2022.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014 (Reapproved 2025).
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014 (Reapproved 2021).
- D. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.
 - 2. Extra Pressure Gauges: One of each type and size.

1.05 FIELD CONDITIONS

- A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 PRODUCTS

2.01 PRESSURE GAUGES

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc.
 - 2. Moeller Instrument Company, Inc.
 - 3. Omega Engineering, Inc.
 - 4. Winters Instruments: www.winters.com/#sle.
 - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Pressure Gauges: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
 - 1. Case: Steel with brass bourdon tube.

2. Size: 4-1/2 inch diameter.
3. Mid-Scale Accuracy: One percent.
4. Scale: Psi.

2.02 PRESSURE GAUGE TAPPINGS

- A. Needle Valve: Brass, 1/4 inch NPT for minimum 150 psi.
- B. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.
- C. Syphon: Steel, Schedule 40, 1/4 inch angle or straight pattern.

2.03 STEM TYPE THERMOMETERS

- A. Manufacturers:
 1. Dwyer Instruments, Inc.
 2. Omega Engineering, Inc: www.omega.com/#sle.
 3. Weksler Glass Thermometer Corp.
 4. Winters Instruments: www.winters.com/#sle.
 5. Substitutions: See Section 016000 - Product Requirements.
- B. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
 1. Size: 9 inch scale.
 2. Window: Clear Lexan.
 3. Stem: 3/4 inch NPT brass.
 4. Accuracy: 2 percent, per ASTM E77.
 5. Calibration: Degrees F.

2.04 DIAL THERMOMETERS

- A. Manufacturers:
 1. Dwyer Instruments, Inc: www.dwyer-inst.com/#sle.
 2. Omega Engineering, Inc: www.omega.com/#sle.
 3. Weksler Glass Thermometer Corp: www.wekslerglass.com/#sle.
 4. Winters Instruments: www.winters.com/#sle.
- B. Thermometer: ASTM E1, stainless steel case, adjustable angle with front recalibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
 1. Size: 5 inch diameter dial.
 2. Lens: Clear glass.
 3. Accuracy: 1 percent.
 4. Calibration: Degrees F.

2.05 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.06 TEST PLUGS

- A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F.

2.07 STATIC PRESSURE GAUGES

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc: www.dwyer-inst.com/#sle.
 - 2. Omega Engineering, Inc: www.omega.com/#sle.
 - 3. Veris Industries: www.veris.com/#sle.
 - 4. Weksler Glass Thermometer Corp: www.wekslerglass.com/#sle.
 - 5. Substitutions: See Section 016000 - Product Requirements.
- B. 3-1/2 inch diameter dial in metal case, diaphragm actuated, black figures on white background, front recalibration adjustment, 2 percent of full scale accuracy.
- C. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch diameter tubing.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge with needle valves for isolation suction and discharge pressure.
- C. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide siphon on gauges in steam systems. Extend nipples and siphons to allow clearance from insulation.
- D. Install pressure gauges on the inlet and outlet piping of all hydronic zones, hydronic coils, and heat transfer equipment.
- E. Install pressure gauges upstream and downstream of all pressure reducing valves.
- F. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- G. Install thermometers in air duct systems on flanges.
- H. Install thermometers in the return duct, outside air duct, inlet duct, and supply duct of all air handling systems and terminal units.
- I. Install thermometers on the inlet and outlet piping of all hydronic zones, hydronic coils, and heat transfer equipment.
- J. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.
- K. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- L. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- M. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- N. Locate test plugs adjacent to pressure gauges and pressure gauge taps.

3.02 SCHEDULE

- A. Pressure Gauges, Location and Scale Range:
 - 1. Pumps, 0 to 150 psi.
 - 2. Expansion tanks, 0 to 150 psi.
 - 3. Pressure reducing valves, 0 to 150 psi.
- B. Pressure Gauge Tappings, Location:
 - 1. Major coils - inlets and outlets.
 - 2. Heat exchangers - inlets and outlets.
 - 3. Boiler - inlets and outlets.
- C. Stem Type Thermometers, Location and Scale Range:
 - 1. Headers to central equipment, 0 to 250 degrees F.
 - 2. Coil banks - inlets and outlets, 0 to 250 degrees F.
 - 3. Heat exchangers - inlets and outlets, 0 to 250 degrees F.
 - 4. Boilers - inlets and outlets, 0 to 250 degrees F.
 - 5. Water zone supply and return, 0 to 250 degrees F.
 - 6. After major coils, 0 to 250 degrees F.
- D. Thermometer Sockets, Location:
 - 1. Reheat coils - inlets and outlets.
 - 2. Cabinet heaters - inlets and outlets.
 - 3. Unit heaters - inlets and outlets.
- E. Dial Thermometers, Location and Scale Range:
 - 1. Each supply air zone, 0 to 120 degrees F.
 - 2. Outside air, 0 to 120 degrees F.
 - 3. Return air, 0 to 120 degrees F.
 - 4. Mixed air, 0 to 120 degrees F.
- F. Static Pressure and Filter Gauges, Location and Scale Range:
 - 1. Built up filter banks, 0 to 3 inches W.C..
 - 2. Unitary filter sections, 0 to 2 inches W.C..

END OF SECTION 230519

**SECTION 230523
GENERAL-DUTY VALVES FOR HVAC PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Ball valves.
- B. Butterfly valves.
- C. Check valves.
- D. Gate valves.
- E. Chainwheels.

1.02 RELATED REQUIREMENTS

- A. Section 083100 - ACCESS DOORS AND PANELS.
- B. Section 230553 - Identification for HVAC Piping and Equipment.
- C. Section 230719 - HVAC Piping Insulation.
- D. Section 232113 - Hydronic Piping.
- E. Section 232213 - Steam and Condensate Heating Piping.

1.03 ABBREVIATIONS AND ACRONYMS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Nonrising stem.
- E. OS&Y: Outside screw and yoke.
- F. PTFE: Polytetrafluoroethylene.
- G. RS: Rising stem.
- H. TFE: Tetrafluoroethylene.
- I. WOG: Water, oil, and gas.

1.04 REFERENCE STANDARDS

- A. ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).
- B. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2020.
- C. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard; 2025.
- D. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves; 2017.
- E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- F. ASME B16.34 - Valves — Flanged, Threaded, and Welding End; 2020.
- G. ASME B31.9 - Building Services Piping; 2025.
- H. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2023).

- I. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings; 2017 (Reapproved 2025).
- J. AWWA C606 - Grooved and Shouldered Joints; 2022.
- K. MSS SP-45 - Drain and Bypass Connections; 2020.
- L. MSS SP-68 - High Pressure Butterfly Valves with Offset Design; 2021.
- M. MSS SP-70 - Gray Iron Gate Valves, Flanged and Threaded Ends; 2011.
- N. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves; 2019.
- O. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.06 QUALITY ASSURANCE

- A. Manufacturer:
 - 1. Obtain valves for each valve type from single manufacturer.
 - 2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Minimize exposure of operable surfaces by setting plug and ball valves to open position.
 - 2. Protect valve parts exposed to piped medium against rust and corrosion.
 - 3. Protect valve piping connections such as grooves, weld ends, threads, and flange faces.
 - 4. Adjust globe, gate, and angle valves to the closed position to avoid clattering.
 - 5. Secure check valves in either the closed position or open position.
 - 6. Adjust butterfly valves to closed or partially closed position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection and protect flanges and specialties from dirt.
 - a. Provide temporary inlet and outlet caps.
 - b. Maintain caps in place until installation.
 - 2. Store valves in shipping containers and maintain in place until installation.
 - a. Store valves indoors in dry environment.
- C. Exercise the following precautions for handling:
 - 1. Handle large valves with sling, modified to avoid damage to exposed parts.
 - 2. Avoid the use of operating handles or stems as rigging or lifting points.

PART 2 PRODUCTS

2.01 APPLICATIONS

-
- A. Listed pipe sizes shown using nominal pipe sizes (NPS) and nominal diameter (DN).
 - B. Provide the following valves for the applications if not indicated on drawings:
 - 1. Throttling (Hydronic): Butterfly and Ball.
 - 2. Isolation (Shutoff): Butterfly and Ball.
 - 3. Swing Check (Pump Outlet):
 - a. Size 2 inch and Smaller: Bronze with bronze disc.
 - b. Size 2-1/2 inch and Larger: Iron with lever and weight, lever and spring, center-guided metal, or center-guided with resilient seat.
 - 4. Dead-End: Butterfly, single-flange (lug) type.
 - C. Required Valve End Connections for Non-Wafer Types:
 - 1. Steel Pipe:
 - a. Size 2 inch and Smaller: Threaded ends.
 - b. 2-1/2 NPS and Larger: Grooved ends or flanged.
 - 2. Copper Tube:
 - a. Size 2 inch and Smaller: Threaded ends, except solder-joint valve-ends.
 - b. Size 2-1/2 inch and Larger: Grooved ends.
 - D. Heating Hot Water Valves:
 - 1. Size 2 inch and Smaller, Brass and Bronze Valves:
 - a. Threaded ends.
 - b. Ball: Full port, two piece, stainless steel trim.
 - c. Swing Check: Bronze disc, Class 125.
 - 2. Size 2-1/2 inch and Larger, Iron Valves:
 - a. 2-1/2 inch to 4 inch: Flanged ends.
 - b. Single-Flange Butterfly: 2-1/2 inch to 12 inch, aluminum-bronze disc, EPDM seat, 200 CWP.
 - c. Grooved-End Butterfly: 2-1/2 inch to 12 inch, 175 CWP.
 - d. Butterfly: High performance, single flange, Class 150.
 - e. Swing Check: Metal seats, Class 125.
 - f. Grooved-End Swing Check: 3 inch to 12 inch, 300 CWP.

2.02 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
 - B. Valve Sizes: Match upstream piping unless otherwise indicated.
 - C. Valve Actuator Types:
 - 1. Handwheel: Valves other than quarter-turn types.
 - 2. Hand Lever: Quarter-turn valves 6 inch and smaller.
 - 3. Wrench: Plug valves with square heads.
 - 4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator, of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
 - D. Valves in Insulated Piping: Provide 2 inch stem extensions and the following features:
 - 1. Gate Valves: Rising stem.
 - 2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - 3. Butterfly Valves: Extended neck.
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- 4. Memory Stops: Fully adjustable after insulation is installed.
 - E. Memory Stops: Fully adjustable after insulation is installed.
 - F. Valve-End Connections:
 - 1. Threaded End Valves: ASME B1.20.1.
 - 2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
 - 3. Pipe Flanges and Flanged Fittings 1/2 inch through 24 inch: ASME B16.5.
 - 4. Solder Joint Connections: ASME B16.18.
 - 5. Grooved End Connections: AWWA C606.
 - G. General ASME Compliance:
 - 1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
 - 2. Building Services Piping Valves: ASME B31.9.
 - H. Bronze Valves:
 - 1. Fabricate from dezincification resistant material.
 - 2. Copper alloys containing more than 15 percent zinc are not permitted.
 - I. Valve Bypass and Drain Connections: MSS SP-45.
 - J. Source Limitations: Obtain each valve type from a single manufacturer.

2.03 BRASS, BALL VALVES

- A. One Piece, Full Port with Brass Trim and Push-to-fit or Threaded Connections:
 - 1. Comply with MSS SP-110.
 - 2. CWP Rating: 200 psi.
 - 3. Body: Forged brass.
 - 4. Ends: Threaded.
 - 5. Seats: PTFE or TFE.
 - 6. Stem: Brass.
 - 7. Ball: Chrome-plated brass.
- B. Two Piece, Full Port with Stainless Steel Trim and Female Thread, Male thread, or Solder Connections:
 - 1. Comply with MSS SP-110.
 - 2. SWP Rating: 150 psi.
 - 3. WOG Rating: 600 psi.
 - 4. Vacuum Rating: 28.9 in-Hg.
 - 5. Body: Forged brass.
 - 6. Seats: PTFE.
 - 7. Stem: Stainless Steel.
 - 8. Ball: Chrome-plated brass.
 - 9. Hose-End Applications: Provide 3/4-inch hose connection. Include cap, gasket, and chain or tether.
- C. Two Piece, Full Port with Press Connection:
 - 1. WOG Rating: 250 psi.
 - 2. Body: Forged brass.
 - 3. Seats: EPDM.
 - 4. Ball: Chrome-plated brass.
 - 5. Blowout Proof Stem: Forged brass.

6. Hose-End Applications: Provide 3/4-inch hose connection. Include cap, gasket, and chain or tether.
7. Maximum Service Temperature: 250 degrees F.

2.04 BRONZE, BALL VALVES

- A. General:
 1. Fabricate from dezincification resistant material.
 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. Two Piece, Full Port with Stainless Steel Trim:
 1. Comply with MSS SP-110.
 2. WSP Rating: 150 psi.
 3. WOG Rating: 400 psi.
 4. Body: Forged bronze or dezincified-brass alloy.
 5. End Connections: Pipe thread or solder.
 6. Seats: PTFE.
 7. Stem: Stainless steel.
 8. Ball: Stainless steel, vented.

2.05 HIGH-PERFORMANCE, SINGLE FLANGE BUTTERFLY VALVES

- A. Lug type; Bidirectional dead end service without downstream flange:
 1. Comply with MSS SP-68.
 2. Class 150: CWP Rating: 285 psi at 100 degrees F.
 3. Body: Provide carbon steel or stainless steel.
 4. Seat: Reinforced PTFE.
 5. Offset stem: Stainless steel.
 6. Disc: Stainless steel.

2.06 BRONZE, SWING CHECK VALVES

- A. Class 150:
 1. Pressure and Temperature Rating: MSS SP-80, Type 3.
 2. Design: Y-pattern, horizontal or vertical flow.
 3. CWP Rating: 300 psi.
 4. Body: Bronze, ASTM B62.
 5. End Connections: Threaded or soldered.
 6. Disc: Bronze.

2.07 IRON, GATE VALVES

- A. NRS or OS&Y:
 1. Comply with MSS SP-70, Type I.
 2. Body Material: Gray iron with bolted bonnet.
 3. Ends: Flanged.
 4. Trim: Bronze.
 5. Disc: Solid wedge.
 6. Packing and Gasket: Asbestos free.

2.08 CHAINWHEELS

- A. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
 1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
 2. Attachment: For connection to ball, butterfly, and plug valve stems.

3. Sprocket Rim with Chain Guides: Ductile iron include zinc coating.
4. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.

PART 3 EXECUTION**3.01 EXAMINATION**

- A. Discard all packing materials and verify that valve interior, including threads and flanges, are completely clean without signs of damage or degradation that could result in leakage.
- B. Verify valve parts to be fully operational in all positions from closed to fully open.
- C. Confirm gasket material to be suitable for the service, to be of correct size, and without defects that could compromise effectiveness.
- D. Should valve is determined to be defective, replace with new valve.

3.02 INSTALLATION

- A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.
- B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.
- C. Install check valves where necessary to maintain direction of flow as follows:
 1. Swing Check: Install horizontal maintaining hinge pin level.
- D. Provide chainwheels on operators for valves 4 NPS and larger where located 96 inches or more above finished floor, terminating 60 inches above finished floor.

END OF SECTION 230523

**SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Support and attachment components.
- B. Retrofit piping cover system.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 055000 - Metal Fabrications: Materials and requirements for fabricated metal supports.

1.03 REFERENCE STANDARDS

- A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.
- B. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2022).
- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2024.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2016a.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping; 2023.
- D. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates; 2024.
- E. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2018).
- F. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2023.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- H. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2024a.
- I. FM (AG) - FM Approval Guide; Current Edition.
- J. MFMA-4 - Metal Framing Standards Publication; 2004.
- K. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.
- L. UL (DIR) - Online Certifications Directory; Current Edition.
- M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.
- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.
1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.
- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.06 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Installer Qualifications for Field-Welding: As specified in Section 055000.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS**2.01 SUPPORT AND ATTACHMENT COMPONENTS**

- A. General Requirements:
1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be

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- supported with a minimum safety factor of 4.0. Include consideration for vibration, equipment operation, and shock loads where applicable.
4. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
 5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Materials for Metal Fabricated Supports: Comply with Section 055000.
- C. Hanger Rods:
1. Threaded zinc-plated steel unless otherwise indicated.
 2. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Piping up to 1 inch: 1/4 inch diameter.
 - c. Piping larger than 1 inch: 3/8 inch diameter.
 - d. Trapeze Support for Multiple Pipes: 3/8 inch diameter.
- D. Thermal Insulated Pipe Supports:
1. Manufacturers:
 - a. Buckaroos, Inc.
 2. General Requirements:
 - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
 - b. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
 - c. Pipe supports to be provided for nominally sized, 1/2 to 30 inch iron pipes.
 - d. Insulation inserts to consist of rigid phenolic foam insulation surrounded by a 360 degree, PVC jacketing.
 3. PVC Jacket:
 - a. Pipe insulation protection shields to be provided with a ball bearing hinge and locking seam.
 - b. Minimum Service Temperature: Minus 40 degrees F.
 - c. Maximum Service Temperature: 180 degrees F.
 - d. Moisture Vapor Transmission: 0.0071 perm inch, when tested in accordance with ASTM E96/E96M.
 - e. Thickness: 60 mil.
 - f. Connections: Brush on welding adhesive.
 4. Pipe insulation protection shields to be provided at the hanger points and guide locations on pipes requiring insulation as indicated on drawings.
 5. Products:
 - a. Buckaroos, Inc; CoolDry.
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- E. Pipe Supports:
 - 1. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
 - 2. Liquid Temperatures Up To 122 degrees F:
 - a. Overhead Support: MSS SP-58 Types 1, 3 through 12.
 - b. Support From Below: MSS SP-58 Types 35 through 38.
 - 3. Operating Temperatures from 122 to 446 degrees F:
 - a. Overhead Support: MSS SP-58 Type 1 or 3 through 12, with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.
 - b. Roller Support: MSS SP-58 Types 41 or 43 through 46, with appropriate saddle of MSS SP-58 Type 39 for insulated pipe.
 - c. Sliding Support: MSS SP-58 Types 35 through 38.
- F. Beam Clamps:
 - 1. Manufacturers:
 - a. Ferguson Enterprises Inc.
 - 2. MSS SP-58 types 19 through 23, 25 or 27 through 30 based on required load.
 - 3. Beam C-Clamp: MSS SP-58 type 23, malleable iron and steel with plain, stainless steel, and zinc finish.
 - 4. Small or Junior Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish. For inverted usage provide manufacturer listed size(s).
 - 5. Wide Mouth Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish.
 - 6. Centerload Beam Clamp with Extension Piece: MSS SP-58 type 30, malleable iron with plain finish.
 - 7. FM (AG) and UL (DIR) Approved Beam Clamp: MSS SP-58 type 19, plain finish,
 - 8. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
 - 9. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
- G. Riser Clamps:
 - 1. Manufacturers:
 - a. Ferguson Enterprises Inc.
 - 2. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
 - 3. MSS SP-58 type 1 or 8, carbon steel or steel with epoxy plated, plain, stainless steel, or zinc plated finish.
 - 4. Medium Split Horizontal Pipe Clamp: MSS SP-58 type 4, carbon steel or stainless steel with epoxy plated, plain, stainless steel, or zinc plated finish.
 - 5. Copper Tube Pipe Clamp: MSS SP-58 type 8, epoxy plated copper.
 - 6. UL (DIR) listed: Pipe sizes 1/2 to 8 inch.
- H. Offset Pipe Clamps: Double-leg design two-piece pipe clamp.
- I. Strut Clamps:
 - 1. Pipe Clamp: Two-piece rigid, universal, or outer diameter type, carbon steel with epoxy copper or zinc finish.
- J. Insulation Clamps:
 - 1. Two bolt-type clamps designed for installation under insulation.

2. Material: Carbon steel with epoxy copper or zinc finish.
- K. Pipe Hangers:
- L. Intermediate Pipe Guides:
 1. Pipe Diameter 6 inch and Smaller: Provide minimum clearance of 0.16 inch.
 2. Pipe Sizes 8 inch: 0.625 inch U-bolt with double nuts providing minimum clearance of 0.28 inch.
 3. Pipe Size 10 inch: 0.75 inch U-bolt.
 4. Pipe Sizes 12 to 16 inch: 0.875 inch U-bolt.
 5. Pipe Sizes 18 to 30 inch: 1 inch U-bolt.
 6. Use pipe clamps with oversize pipe sleeve that provides clearance around pipe.
- M. Pipe Alignment Guides:
 1. Pipe Sizes 8 inch and Smaller: Spider or sleeve type.
 2. Pipe Sizes 10 inch and Larger: Roller type.
- N. Dielectric Barriers: Provide between metallic supports and metallic piping and associated items of dissimilar type; acceptable dielectric barriers include rubber or plastic sheets or coatings attached securely to pipe or item.
- O. Pipe Shields for Insulated Piping:
 1. Manufacturers:
 - a. Anvil International.
 2. General Construction and Requirements:
 - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
 - b. Shields Material: UV-resistant polypropylene with glass fill.
 - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
 - d. Minimum Service Temperature: Minus 40 degrees F.
 - e. Maximum Service Temperature: 178 degrees F.
 - f. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- P. Anchors and Fasteners:
 1. Manufacturers - Mechanical Anchors:
 - a. Hilti, Inc.
 - b. ITW Red Head, a division of Illinois Tool Works, Inc.
 - c. Powers Fasteners, Inc.
 - d. Simpson Strong-Tie Company Inc.
 2. Manufacturers - Powder-Actuated Fastening Systems:
 - a. Hilti, Inc.
 - b. ITW Ramset, a division of Illinois Tool Works, Inc.
 - c. Powers Fasteners, Inc.
 - d. Simpson Strong-Tie Company Inc.
 3. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
 4. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
 5. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
 6. Hollow Masonry: Use toggle bolts.
 7. Hollow Stud Walls: Use toggle bolts.

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8. Sheet Metal: Use sheet metal screws.
 9. Wood: Use wood screws.
 10. Plastic and lead anchors are not permitted.
 11. Hammer-driven anchors and fasteners are not permitted.
 12. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch minimum base metal thickness.
 - d. Manufacturer: Same as manufacturer of metal channel (strut) framing system.
 13. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.
- Q. Pipe Installation Accessories:
1. Copper Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation.
 2. Thermal Insulated, Surface-Mounted Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation.
 - b. Material: Carbon steel with epoxy copper or zinc finish.
 - c. Weather and UV light resistant foam, plastic, or rubber material with built-in strut.
Maximum Load: 50 lb for single pipe or multiple landed on top strut.
 3. Overhead Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation.
 4. Plenum Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation.
 5. Telescoping Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation..
 6. Inserts and Clamps:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation.

2.02 RETROFIT PIPING COVER SYSTEM

- A. Manufacturers:
 1. DecoShield Systems, Inc.
 - B. General Requirements:
 1. Surface Burning Characteristics: Flame spread index/smoke developed index of 20/250, maximum, when tested in accordance with ASTM E84 or UL 723.
 - C. Materials:
 1. Piping Cover System: Removal-resistant, modular, snap-fit cover units, clips, and anchors for use with CPVC, steel, and copper piping systems.
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2. Cover Units: L-shaped and U-shaped cross-section units of flame retardant resin material, paintable finish.
3. Unit Length: 7.5 feet.
4. Provide coupling fittings for joining units end to end and prefabricated inside and outside corner fittings and end caps as required.
5. Provide mounting clips to secure covers to wall-ceiling per manufacturer requirements.

PART 3 EXECUTION**3.01 EXAMINATION**

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- D. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Field-Welding (where approved by Architect): Comply with Section 055000.
- H. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.
- I. Equipment Support and Attachment:
 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
- J. Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.
- K. Secure fasteners according to manufacturer's recommended torque settings.
- L. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION 230529

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**SECTION 230550
WIND RESTRAINT FOR HVAC SYSTEMS**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary General Conditions and other Division 1 Specification Sections, apply to this Section.

1.02 SECTION INCLUDES

- A. Support and brace mechanical and electrical systems, as called for, to resist directional wind forces (lateral, longitudinal and vertical).

1.03 APPLICABLE CODES AND STANDARDS

- A. Provide work in compliance with the following codes and standards:
 - 1. 2020 International Building Code (Section 1609).
 - 2. 2020 International Mechanical Code (Section 301, Item 301.15).
 - 3. American Society of Civil Engineers (ASCE) Minimum Design Loads for Buildings and Other Structures with Supplement No. 1 - Standard ASCE/SEI 7-10.

1.04 QUALITY ASSURANCE

- A. General:
 - 1. The contractor shall coordinate with the general contractor before any installation of curbs, rails or roof supports are installed.
 - 2. The contractor shall provide all hardware associated with the requirements of the calculations.
 - 3. The contractor shall provide professional engineer stamped and signed calculations, and details of wind restraint systems to meet total design lateral force requirements for support and restraint of mechanical and electrical systems.
 - 4. Systems requiring wind restraint including, but not limited to:
 - a. Exhaust fans.
 - b. Hooded intake or relief ventilators.
 - c. Ductwork.
 - d. Rooftop air handling equipment.
 - e. Outdoor refrigeration units.
 - f. Miscellaneous HVAC equipment.
 - g. Roof curbs and pipe/duct/equipment supports associated with any of the equipment listed above.

1.05 SUBMITTALS

- A. Submit wind force level (Fp) calculations from applicable building code. Submit pre- approved restraint selections, installation details, and plans indicating locations of restraints.
- B. Calculations, plans, restraint selection, and installation details shall be stamped and signed by a professionally licensed engineer experienced in wind restraint design.
- C. Submit manufacturer's product data.
- D. For each piece of equipment that requires wind restraint as outlined in this section, include the following:
 - 1. Dimensioned Outline Drawings of Equipment Unit: Identify the center of gravity and locate and describe mounting and anchoring provisions.

2. Anchorage: Provide detailed description of equipment anchorage devices on which the calculations are based and their installation requirements. Identify anchor bolts, studs and other mounting devices. Provide information on the size, type and spacing of mounting brackets, holes and other provisions.
 3. Hardware needed to complete the installation.
- E. Supports determined to be required to meet wind restraint requirements are separate from any additional supports required for system components (i.e. ductwork, piping). Additional supports required for system components shall be submitted with appropriate specification section.

PART 1 PRODUCTS

2.01 CODE INFORMATION

- A. This project is subject to the wind bracing requirements of the 2015 International Building Code (Section 1609) and American Society of Civil Engineers ASCE/SEI 7-10. The following criteria are applicable to this project:
1. Nominal Design Wind Speed (V) (Per ASCE 7-10): 120 mph.
 2. Risk Category (Per ASCE 7-10): III
 3. Exposure Category (Per ASCE 7-10): C
 4. Height and Exposure Adjustment Coefficient (Per ASCE 7-10): 1.21

2.02 WIND BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

- A. General:
1. Design analysis shall include calculated dead loads, wind loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
 2. Analysis shall detail anchoring methods, bolt diameter, and embedment depth.
 3. All wind restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 2.1.
- B. Friction from gravity loads shall not be considered resistance to wind forces.

PART 1 EXECUTION

3.01 INSTALLATION

- A. Wind Restraint of Ductwork and Equipment:
1. All restraint systems shall be installed in strict accordance with the manufacturer's restraint guidelines and all certified submittal data.
 2. **MC to provide all hardware required for the installation.** Provide to the general contractor.
 3. Only supports required to meet the wind restraint requirements are included in this section.
 4. The interaction between mechanical and electrical equipment and the supporting structures shall be designed into the restraint systems.
 5. Friction clips shall not be used for anchorage attachments.
 6. Expansion anchors shall not be used for non-vibration isolated equipment rated over 10 HP.
 7. Components mounted on vibration isolation systems shall have a bumper restraint or snubber in each horizontal direction and vertical restraints shall be provided to resist overturning.
 8. Installation of restraints shall not cause any change in position of equipment or ductwork, resulting in stresses or misalignment.

9. Exhaust fans with hinge kits shall have wind restraint fasteners installed on the hinged side, same as the three (3) non-hinged sides.
10. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.
11. Do not install any equipment or duct that makes rigid connections with the building unless isolation is not specified.
12. Prior to installation, bring to the Architect's/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
13. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult Structural Engineer of record.
14. Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The Contractor shall submit loads to the Structural Engineer of record for approval in this event.
15. Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
16. Provide reinforced clevis bolts where required.
17. Do not brace a system to two independent structures such as a roof and wall.

END OF SECTION 230550

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**SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Adhesive-backed duct markers.
- D. Stencils.
- E. Pipe markers.
- F. Ceiling tacks.

1.02 RELATED REQUIREMENTS

- A. Section 099123 - Interior Painting: Identification painting.

1.03 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2025.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- F. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates.
- B. Control Panels: Nameplates.
- C. Dampers: Ceiling tacks, where located above lay-in ceiling.
- D. Ductwork: Adhesive-backed duct markers or stencils.
- E. Major Control Components: Nameplates.
- F. Piping: Pipe markers.

2.02 NAMEPLATES

- A. Manufacturers:
 - 1. Advanced Graphic Engraving, LLC.
 - 2. Brimar Industries, Inc.
 - 3. Craftmark Pipe Markers.
 - 4. Kolbi Pipe Marker Co.
 - 5. Seton Identification Products, a Tricor Direct Company.

- B. Letter Color: White.
- C. Letter Height: 1/4 inch.
- D. Background Color: Black.
- E. Plastic: Comply with ASTM D709.

2.03 TAGS

- A. Manufacturers:
 - 1. Advanced Graphic Engraving.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc: www.pipemarker.com/#sle.
 - 4. Craftmark Pipe Markers.
 - 5. Kolbi Pipe Marker Co.
 - 6. Seton Identification Products, a Tricor Company.
- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- C. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- D. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.04 ADHESIVE-BACKED DUCT MARKERS

- A. Manufacturers:
 - 1. Brimar Industries, Inc.
 - 2. Craftmark Pipe Markers.
 - 3. Seton Identification Products, a Tricor Company.
- B. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch; printed with UV and chemical resistant inks.
- C. Style: Individual Label.
- D. Color: Green/White Green/White.

2.05 STENCILS

- A. Manufacturers:
 - 1. Brady Corporation.
 - 2. Craftmark Pipe Markers.
 - 3. Insite Solutions, LLC.
 - 4. Kolbi Pipe Marker Co.
 - 5. Seton Identification Products, a Tricor Company.
- B. Stencils: With clean cut symbols and letters of following size:
 - 1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
 - 2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
 - 3. 2-1/2 to 6 inch Outside Diameter of Insulation or Pipe: 12 inch long color field, 1-1/4 inch high letters.
 - 4. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.

- 5. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
- 6. Ductwork and Equipment: 2-1/2 inch high letters.
- C. Stencil Paint: As specified in Section 099123, semi-gloss enamel, colors complying with ASME A13.1.

2.06 PIPE MARKERS

- A. Manufacturers:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Craftmark Pipe Markers.
 - 4. Kolbi Pipe Marker Co.
 - 5. Seton Identification Products, a Tricor Company.
- B. Color: Comply with ASME A13.1.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.
- E. Color code as follows:
 - 1. Heating, Cooling, and Boiler Feedwater: Green with white letters.

2.07 CEILING TACKS

- A. Manufacturers:
 - 1. Craftmark Pipe Markers.
- B. Description: Steel with 3/4 inch diameter color coded head.
- C. Color code as follows:
 - 1. HVAC Equipment: Yellow.
 - 2. Fire Dampers and Smoke Dampers: Red.
 - 3. Heating/Cooling Valves: Blue.

PART 3 EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 099123 for stencil painting.

3.02 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Use tags on piping 3/4 inch diameter and smaller.
 - 1. Identify service, flow direction, and pressure.

- 2. Install in clear view and align with axis of piping.
- 3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- F. Install ductwork with adhesive-backed duct markers. Identify with air handling unit identification number and area served. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
- G. Locate ceiling tacks to locate dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 230553

SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Testing, adjustment, and balancing of air systems.
- B. Testing, adjustment, and balancing of hydronic and refrigerating systems.
- C. Measurement of final operating condition of HVAC systems.

1.02 RELATED REQUIREMENTS

- A. Section 019113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.

1.03 REFERENCE STANDARDS

- A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition; 2016.
- B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2024, with Errata (2025).
- C. NEBB (TAB) - Procedural Standard for Testing, Adjusting and Balancing of Environmental Systems; 2019, with Errata (2022).
- D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2023.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- C. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Submit to Architect.
 - 2. Submit to the Commissioning Provider and Construction Manager.
 - 3. Include at least the following in the plan:
 - a. Preface: An explanation of the intended use of the control system.
 - b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - d. Identification and types of measurement instruments to be used and their most recent calibration date.
 - e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - f. Final test report forms to be used.
 - g. Detailed step-by-step procedures for TAB work for each system and issue, including:
 - 1) Terminal flow calibration (for each terminal type).
 - 2) Diffuser proportioning.
 - 3) Branch/submain proportioning.
 - 4) Total flow calculations.

-
- 5) Rechecking.
 - 6) Diversity issues.
 - h. Expected problems and solutions, etc.
 - i. Details of how TOTAL flow will be determined; for example:
 - 1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
 - 2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
 - j. Confirmation of understanding of the outside air ventilation criteria under all conditions.
 - k. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
 - l. Method of checking building static and exhaust fan and/or relief damper capacity.
 - m. Procedures for formal deficiency reports, including scope, frequency and distribution.
- D. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
- 1. Submit to the Commissioning Provider and Construction Manager within two weeks after completion of testing, adjusting, and balancing.
 - 2. Revise TAB plan to reflect actual procedures and submit as part of final report.
 - 3. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
 - 4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
 - 5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
 - 6. Units of Measure: Report data in I-P (inch-pound) units only.
 - 7. Include the following on the title page of each report:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone number of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Architect.
 - g. Project Engineer.
 - h. Project Contractor.
 - i. Report date.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 - 1. AABC (NSTSB), AABC National Standards for Total System Balance.
 - 2. SMACNA (TAB).
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.

- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
 - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 - 2. Having minimum of three years documented experience.
 - 3. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.02 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Fire and volume dampers are in place and open.
 - 8. Air coil fins are cleaned and combed.
 - 9. Access doors are closed and duct end caps are in place.
 - 10. Air outlets are installed and connected.
 - 11. Duct system leakage is minimized.
 - 12. Hydronic systems are flushed, filled, and vented.
 - 13. Pumps are rotating correctly.
 - 14. Service and balance valves are open.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

3.03 PREPARATION

- A. Provide instruments required for testing, adjusting, and balancing operations.
- B. Provide additional balancing devices as required.

3.04 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
- C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.05 RECORDING AND ADJUSTING

- A. Field Logs: Maintain written logs including:
 - 1. Running log of events and issues.
 - 2. Discrepancies, deficient or uncompleted work by others.
 - 3. Contract interpretation requests.
 - 4. Lists of completed tests.
- B. Ensure recorded data represents actual measured or observed conditions.
- C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- D. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.
- F. Check and adjust systems approximately six months after final acceptance and submit report.

3.06 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- E. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- F. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- G. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- H. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- I. Where modulating dampers are provided, take measurements and balance at extreme conditions.

3.07 WATER SYSTEM PROCEDURE

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gauges to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect system balance with automatic control valves fully open to heat transfer elements.

- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.08 SCOPE

- A. Test, adjust, and balance the following:
 - 1. HVAC Pumps.
 - 2. Heating Hot Water Boilers.
 - 3. Refrigerant based heat/cooling systems (VRF)
 - 4. Packaged Roof Top Heating/Cooling Units.
 - 5. Computer Room Air Conditioning Units.
 - 6. Air Coils.
 - 7. Air Handling Units.
 - 8. Fans.
 - 9. Air Filters.
 - 10. Air Terminal Units.
 - 11. Air Inlets and Outlets.

3.09 MINIMUM DATA TO BE REPORTED

- A. Electric Motors:
 - 1. Manufacturer.
 - 2. Model/Frame.
 - 3. HP/BHP.
 - 4. Phase, voltage, amperage; nameplate, actual, no load.
 - 5. RPM.
 - 6. Service factor.
 - 7. Starter size, rating, heater elements.
 - 8. Sheave Make/Size/Bore.
- B. V-Belt Drives:
 - 1. Identification/location.
 - 2. Required driven RPM.
 - 3. Driven sheave, diameter and RPM.
 - 4. Belt, size and quantity.
 - 5. Motor sheave diameter and RPM.
 - 6. Center to center distance, maximum, minimum, and actual.
- C. Pumps:
 - 1. Identification/number.
 - 2. Manufacturer.
 - 3. Size/model.
 - 4. Impeller.
 - 5. Service.
 - 6. Design flow rate, pressure drop, BHP.
 - 7. Actual flow rate, pressure drop, BHP.
 - 8. Discharge pressure.
 - 9. Suction pressure.
 - 10. Total operating head pressure.

11. Shut off, discharge and suction pressures.
 12. Shut off, total head pressure.
- D. Air Cooled Condensers and VRF Outdoor Units:
1. Identification/number.
 2. Location.
 3. Manufacturer.
 4. Model number.
 5. Serial number.
 6. Number of compressors.
- E. Cooling Coils:
1. Identification/number.
 2. Location.
 3. Service.
 4. Manufacturer.
 5. Air flow, design and actual.
 6. Entering air DB temperature, design and actual.
 7. Entering air WB temperature, design and actual.
 8. Leaving air DB temperature, design and actual.
 9. Leaving air WB temperature, design and actual.
 10. Water flow, design and actual.
 11. Water pressure drop, design and actual.
 12. Entering water temperature, design and actual.
 13. Leaving water temperature, design and actual.
 14. Air pressure drop, design and actual.
- F. Heating Coils:
1. Identification/number.
 2. Location.
 3. Service.
 4. Manufacturer.
 5. Air flow, design and actual.
 6. Water flow, design and actual.
 7. Water pressure drop, design and actual.
 8. Entering water temperature, design and actual.
 9. Leaving water temperature, design and actual.
 10. Entering air temperature, design and actual.
 11. Leaving air temperature, design and actual.
 12. Air pressure drop, design and actual.
- G. Electric Duct Heaters:
1. Manufacturer.
 2. Identification/number.
 3. Location.
 4. Model number.
 5. Design kW.
 6. Number of stages.
 7. Phase, voltage, amperage.
 8. Test voltage (each phase).
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9. Test amperage (each phase).
 10. Air flow, specified and actual.
 11. Temperature rise, specified and actual.
- H. Air Moving Equipment:
1. Location.
 2. Manufacturer.
 3. Model number.
 4. Serial number.
 5. Arrangement/Class/Discharge.
 6. Air flow, specified and actual.
 7. Return air flow, specified and actual.
 8. Outside air flow, specified and actual.
 9. Total static pressure (total external), specified and actual.
 10. Inlet pressure.
 11. Discharge pressure.
 12. Sheave Make/Size/Bore.
 13. Number of Belts/Make/Size.
 14. Fan RPM.
- I. Return Air/Outside Air:
1. Identification/location.
 2. Design air flow.
 3. Actual air flow.
 4. Design return air flow.
 5. Actual return air flow.
 6. Design outside air flow.
 7. Actual outside air flow.
 8. Return air temperature.
 9. Outside air temperature.
 10. Required mixed air temperature.
 11. Actual mixed air temperature.
 12. Design outside/return air ratio.
 13. Actual outside/return air ratio.
- J. Exhaust Fans:
1. Location.
 2. Manufacturer.
 3. Model number.
 4. Serial number.
 5. Air flow, specified and actual.
 6. Total static pressure (total external), specified and actual.
 7. Inlet pressure.
 8. Discharge pressure.
 9. Sheave Make/Size/Bore.
 10. Number of Belts/Make/Size.
 11. Fan RPM.
- K. Duct Traverses:
1. System zone/branch.
-

2. Duct size.
 3. Area.
 4. Design velocity.
 5. Design air flow.
 6. Test velocity.
 7. Test air flow.
 8. Duct static pressure.
- L. Air Monitoring Stations:
1. Identification/location.
 2. System.
 3. Size.
 4. Area.
 5. Design velocity.
 6. Test velocity.
 7. Test air flow.
- M. Flow Measuring Stations:
1. Identification/number.
 2. Location.
 3. Size.
 4. Manufacturer.
 5. Model number.
 6. Serial number.
 7. Design Flow rate.
 8. Design pressure drop.
 9. Actual/final pressure drop.
 10. Actual/final flow rate.
 11. Station calibrated setting.
- N. Terminal Unit Data:
1. Manufacturer.
 2. Type, constant, variable, single, dual duct.
 3. Identification/number.
 4. Location.
 5. Model number.
 6. Size.
 7. Minimum static pressure.
 8. Minimum design air flow.
 9. Maximum design air flow.
 10. Maximum actual air flow.
 11. Inlet static pressure.
- O. Air Distribution Tests:
1. Air terminal number.
 2. Room number/location.
 3. Terminal type.
 4. Terminal size.
 5. Area factor.
 6. Design velocity.
-

7. Design air flow.
8. Test (final) velocity.
9. Test (final) air flow.
10. Percent of design air flow.

END OF SECTION 230593

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**SECTION 230713
DUCT INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Duct insulation.
- B. Duct liner.
- C. Jacketing and accessories.

1.02 RELATED REQUIREMENTS

- A. Section 230553 - Identification for HVAC Piping and Equipment.
- B. Section 233100 - HVAC Ducts and Casings: Glass fiber ducts.

1.03 REFERENCE STANDARDS

- A. ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- B. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2007 (Reapproved 2024).
- C. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2026.
- D. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2024.
- E. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014 (Reapproved 2019).
- F. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2023).
- G. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation; 2020.
- H. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2025.
- I. ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings; 2019.
- J. ASTM C1371 - Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers; 2015.
- K. ASTM C1423 - Standard Guide for Selecting Jacketing Materials for Thermal Insulation; 2021.
- L. ASTM D93 - Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester; 2020.
- M. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- N. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2024a.
- O. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015 (Reapproved 2021)e1.

- P. SAE AMS3779 - Tape, Adhesive, Pressure-Sensitive Thermal Radiation Resistant, Aluminum Coated Glass Cloth; 2016b.
- Q. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- R. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013300 Submittal Procedures for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.07 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
 - 1. CertainTeed Corporation: www.certainteed.com/#sle.
 - 2. Johns Manville: www.jm.com/#sle.
 - 3. Knauf Insulation: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation: www.ocbuildingspec.com/#sle.
 - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. K value: 0.36 at 75 degrees F.
 - 2. Maximum Service Temperature: 250 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket:
 - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.

2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
3. Secure with pressure-sensitive tape.
- D. Vapor Barrier Tape:
 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure-sensitive rubber-based adhesive.
- E. Indoor Vapor Barrier Mastic:
 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- F. Outdoor Vapor Barrier Mastic:
 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- G. Tie Wire: Annealed steel, 16 gauge, 0.0508 inch diameter.

2.03 GLASS FIBER, RIGID

- A. Manufacturer:
 1. CertainTeed Corporation: www.certainteed.com/#sle.
 2. Johns Manville: www.jm.com/#sle.
 3. Knauf Insulation: www.knaufinsulation.com/#sle.
 4. Owens Corning Corporation; 700 Series FIBERGLAS Insulation: www.owenscorning.com/en-us/#sle.
 5. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: ASTM C612; rigid, noncombustible.
 1. K Value: 0.24 at 75 degrees F.
 2. Maximum Service Temperature: 450 degrees F.
 3. Maximum Water Vapor Absorption: 5.0 percent.
 4. Maximum Density: 8.0 pcf.
- C. Vapor Barrier Jacket:
 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 3. Secure with pressure-sensitive tape.
- D. Vapor Barrier Tape:
 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure-sensitive rubber-based adhesive.
- E. Indoor Vapor Barrier Finish:
 1. Cloth: Untreated; 9 oz/sq yd weight, glass fabric.
 2. Vinyl emulsion type acrylic, compatible with insulation, black color.

2.04 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

2.05 JACKETING AND ACCESSORIES

- A. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire-retardant lagging adhesive.
 1. Lagging Adhesive:

- a. Manufacturers:
 - 1) Design Polymerics; DP 3050 Water Based, Premium Quality, Lagging Adhesive, and Vapor Retarder: www.designpoly.com/#sle.
 - 2) Substitutions: See Section 016000 - Product Requirements
- b. Compatible with insulation.
- B. Aluminum Jacket:
 - 1. Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
 - 2. Thickness: 0.016 inch sheet.
 - 3. Finish: Smooth.
 - 4. Joining: Longitudinal slip joints and 2 inch laps.
 - 5. Fittings: 0.016 inch thick die-shaped fitting covers with factory-attached protective liner.
 - 6. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
- C. Flexible Weather-Proofing Outdoor Jacket: Self-healing, field-applied outdoor cladding.
 - 1. Material: Aluminum foil/polymer laminate with rubberized asphalt layer and acrylic adhesive.
 - 2. Thickness: 34 mil, 0.034 inch.
 - 3. Finish: Embossed.
 - 4. Color: Silver.
 - 5. Water Vapor Transmission: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - 6. Mold Resistance: Pass when tested in accordance with ASTM C1338.
 - 7. Emissivity: 0.30 when tested in accordance with ASTM C1371.
- D. Reinforced Tape:
 - 1. FSK tape suitable for sealing seams between insulation, insulated elbows, and fittings resulting in a tight, smooth surface without wrinkles.
 - 2. Comply with UL 723 or ASTM E84.
 - 3. Moisture Vapor Permeability: 0.00 perm inch, when tested in accordance with ASTM E96/E96M.
 - 4. Finish: Match insulation.
- E. Plain Foil Tape:
 - 1. Aluminum foil with pressure-sensitive adhesive on paper release liner.
 - 2. Finish: Plain foil.

2.06 DUCT LINER

- A. Manufacturers:
 - 1. CertainTeed Corporation: www.certainteed.com/#sle.
 - 2. Johns Manville: www.jm.com/#sle.
 - 3. Knauf Insulation; Performance+ Duct Liner: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation: www.ocbuildingspec.com/#sle.
 - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Glass Fiber Insulation: Non-corrosive, incombustible glass fiber complying with ASTM C1071; flexible blanket, rigid board, and preformed round liner board; impregnated surface and edges coated with poly vinyl acetate polymer, acrylic polymer, or black composite.
 - 1. Fungal Resistance: No growth when tested according to ASTM G21.
 - 2. Apparent Thermal Conductivity: Maximum of 0.31 at 75 degrees F.

3. Service Temperature: Up to 250 degrees F.
4. Rated Velocity on Coated Air Side for Air Erosion: 5,000 fpm, minimum.
5. Minimum Noise Reduction Coefficients:
 - a. 1/2 inch Thickness: 0.30.
 - b. 1 inch Thickness: 0.45.
- C. Adhesive: Waterproof, fire-retardant type, ASTM C916.
 1. Manufacturers:
 - a. Design Polymeric; DP 2502 Water Based, Low VOC, Duct Liner Adhesive:
www.designpoly.com/#sle.
 - b. Elgen Manufacturing Company, Inc; Water Based Liner Adhesive:
www.elgenmfg.com/#sle.
 - c. Substitutions: See Section 016000 - Product Requirements
- D. Liner Fasteners: Galvanized steel, self-adhesive pad with integral head.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Test ductwork for design pressure prior to applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Insulated Ducts Conveying Air Below Ambient Temperature:
 1. Provide insulation with vapor barrier jackets.
 2. Finish with tape and vapor barrier jacket.
 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 4. Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- C. Insulated Ducts Conveying Air Above Ambient Temperature:
 1. Provide with standard vapor barrier jacket.
 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- D. Ducts Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet above finished floor): Finish with canvas jacket sized for finish painting.
- E. Slope exterior ductwork to shed water.
- F. External Duct Insulation Application:
 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
 2. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
 3. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
- G. Duct and Plenum Liner Application:
 1. Adhere insulation with adhesive for 90 percent coverage.
 2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
 3. Seal and smooth joints. Seal and coat transverse joints.
 4. Seal liner surface penetrations with adhesive.

5. Duct dimensions indicated are net inside dimensions required for airflow. Increase duct size to allow for insulation thickness.

3.03 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078400 "Firestopping."

3.04 SCHEDULES

- A. Exhaust and Relief Ducts Within 10 ft of Exterior Openings:
 1. Flexible Glass Fiber Duct Insulation: 1-1/2 inches thick.
 2. Rigid Glass Fiber Duct Insulation: 1-1/2 inches thick.
- B. Outside Air Intake and Combustion Air Ducts:
 1. Insulation:
 - a. Flexible Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-12.
 - b. Rigid Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-12.
- C. Supply Ducts:
 1. First 10 ft from unit supply/return connections
 - a. Duct Liner
 2. Other than first 10 ft from supply connection
 - a. Flexible Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-6.
 - b. Rigid Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-6.
- D. Supply, Exhaust, Return and Relief Ducts in Mechanical Rooms:
 1. Insulation:
 - a. Flexible Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-6.
 - b. Rigid Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-6.
 2. Jacket:
 - a. Canvas jacket.
- E. Concealed or exposed Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation:
 1. Fire-rated blanket; thickness as required to achieve 2-hour fire rating.
- F. Ducts Exposed to Outdoors:
 1. Insulation:
 - a. Flexible Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-12.
 - b. Rigid Glass Fiber Duct Insulation:
 - 1) Thickness required to provide an R value not less than R-12.
 2. Jacket:

- a. Aluminum Jacket or Flexible Weather-Proofing Outdoor Jacket

END OF SECTION 230713

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**SECTION 230716
HVAC EQUIPMENT INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Equipment insulation.
- B. Jacketing and accessories.
- C. Breeching insulation.

1.02 RELATED REQUIREMENTS

- A. Section 232113 - Hydronic Piping: Placement of hangers and hanger inserts.
- B. Section 232114 - Hydronic Specialties.

1.03 REFERENCE STANDARDS

- A. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2024).
- B. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2007 (Reapproved 2024).
- C. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation; 2017 (Reapproved 2023).
- D. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2024.
- E. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2016.
- F. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014 (Reapproved 2019).
- G. ASTM C1393 - Standard Specification for Perpendicularly Oriented Mineral Fiber Roll and Sheet Thermal Insulation for Pipes and Tanks; 2025.
- H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- I. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2024a.
- J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with not less than three years of documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.07 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER, FLEXIBLE

- A. Manufacturers:
 - 1. CertainTeed Corporation: www.certainteed.com/#sle.
 - 2. Johns Manville Corporation: www.jm.com/#sle.
 - 3. Knauf Insulation: www.knaufinsulation.com/#sle.
 - 4. Manson Insulation, a company of Knauf Insulation: www.imanson.com/#sle.
 - 5. Owens Corning Corporation: www.owenscorning.com/en-us/#sle.
- B. Insulation: ASTM C553; flexible, noncombustible.
 - 1. K Value: 0.36 at 75 degrees F.
 - 2. Maximum Service Temperature: 1,000 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Insulation: ASTM C1393; pipe and tank, end grain adhered to jacket.
 - 1. K Value: 0.27 at 75 degrees F.
 - 2. Maximum Service Temperature: 850 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- D. Vapor Barrier Jacket: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 2. Secure with self-sealing longitudinal laps and butt strips.
- E. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- F. Vapor Barrier Lap Adhesive: Compatible with insulation.
- G. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.03 GLASS FIBER, RIGID

- A. Manufacturer:
 - 1. CertainTeed Corporation: www.certainteed.com/#sle.
 - 2. Johns Manville Corporation: www.jm.com/#sle.
 - 3. Knauf Insulation: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation: www.owenscorning.com/en-us/#sle.

- B. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.
 - 1. K Value: 0.25 at 75 degrees F.
 - 2. Maximum Service Temperature: 1,200 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
 - 4. Maximum Density: 8.0 pcf.
- C. Vapor Barrier Jacket:
 - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 3. Secure with self-sealing longitudinal laps and butt strips.
- D. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.
- E. Vapor Barrier Lap Adhesive: Compatible with insulation.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.04 HYDROUS CALCIUM SILICATE

- A. Insulation: ASTM C533; rigid molded, asbestos free, gold color.
 - 1. K Value: 0.40 at 300 degrees F.
 - 2. Maximum Service Temperature: 1,200 degrees F.
 - 3. Density: 15 pcf.
- B. Tie Wire: 0.048 inches stainless steel with twisted ends on maximum 12 inch centers.
- C. Insulating Cement: ASTM C449.

2.05 JACKETING AND ACCESSORIES

- A. Canvas Jacket: UL listed 6 oz/sq yd plain weave cotton fabric treated with dilute fire-retardant lagging adhesive.
 - 1. Lagging Adhesive: Compatible with insulation.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that equipment has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Factory Insulated Equipment: Do not insulate.
- C. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
- F. Insulated equipment containing fluids below ambient temperature; insulate entire system.
- G. Fiber glass insulated equipment containing fluids below ambient temperature; provide vapor barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapor barrier adhesive.

- H. For hot equipment containing fluids 140 degrees F or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
- I. Fiber glass insulated equipment containing fluids above ambient temperature; provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
- J. Finish insulation at supports, protrusions, and interruptions.
- K. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.
- L. Cover glass fiber insulation with metal mesh and finish with heavy coat of insulating cement.
- M. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- N. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

3.03 SCHEDULE

- A. Heating Systems:
 - 1. Pump Bodies:
 - 2. Heat Exchangers/Converters:
 - 3. Air Separators:
 - 4. Flue Gas Breeching:

END OF SECTION 230716

**SECTION 230719
HVAC PIPING INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping insulation.
- B. Flexible removable and reusable blanket insulation.
- C. Jacketing and accessories.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 232113 - Hydronic Piping: Placement of hangers and hanger inserts.
- C. Section 232213 - Steam and Condensate Heating Piping: Placement of hangers and hanger inserts.
- D. Section 232300 - Refrigerant Piping: Placement of inserts.

1.03 REFERENCE STANDARDS

- A. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus; 2019.
- B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2024).
- C. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2007 (Reapproved 2024).
- D. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2026.
- E. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2022a.
- F. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2022.
- G. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation; 2023.
- H. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2023).
- I. ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation; 2023.
- J. ASTM D610 - Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces; 2025.
- K. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- L. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2024a.
- M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.

- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum 5 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.07 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER, RIGID

- A. Manufacturers:
 - 1. CertainTeed Corporation.
 - 2. Johns Manville Corporation.
 - 3. Knauf Insulation; Earthwool 1000 Degree Pipe Insulation.
 - 4. Owens Corning Corporation; Fiberglas Pipe Insulation ASJ.
 - 5. Owens Corning Corporation; VaporWick Pipe Insulation.
 - 6. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
 - 1. K Value: 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: 850 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
- D. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- E. Vapor Barrier Lap Adhesive: Compatible with insulation.
- F. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
- G. Fibrous Glass Fabric:
 - 1. Cloth: Untreated; 9 oz/sq yd weight.
 - 2. Blanket: 1.0 pcf density.
 - 3. Weave: 5 by 5.

- H. Indoor Vapor Barrier Finish:
 - 1. Cloth: Untreated; 9 oz/sq yd weight.
 - 2. Vinyl emulsion type acrylic, compatible with insulation, black color.
- I. Outdoor Vapor Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- J. Insulating Cement: ASTM C449.

2.03 CELLULAR GLASS

- A. Manufacturers:
 - 1. Owens Corning Corporation; FOAMGLAS: www.owenscorning.com/en-us/#sle.
 - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Pipe and Tubing Insulation: ASTM C552, Type II, Grade 6.
 - 1. K Value: 0.35 at 100 degrees F.
 - 2. Service Temperature Range: From 250 degrees F to 800 degrees F.
 - 3. Water Vapor Permeability: 0.005 perm inch maximum per inch.
 - 4. Water Absorption: 0.5 percent by volume, maximum.
 - 5. Density: A minimum of 6.12 pcf.

2.04 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturers:
 - 1. Aeroflex USA, Inc; Aerocel Stay-Seal with Protape (SSPT).
 - 2. Armacell LLC; ArmaFlex Ultra with FlameDefense.
 - 3. K-Flex USA LLC; K-Flex Titan.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
 - 1. Minimum Service Temperature: Minus 40 degrees F.
 - 2. Maximum Service Temperature: 180 degrees F.
 - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.05 EXTRUDED POLYSTYRENE (XPS) BOARD INSULATION

- A. Comply with ASTM E84.
- B. Insulation: ASTM C578; rigid closed cell.
 - 1. K Value: 0.23 at 75 degrees F.
 - 2. Maximum Service Temperature: 165 degrees F.
 - 3. Maximum Water Vapor Permeance: 5.0 perm.
- C. Billet Dimensions: 7 inches by 14 inches by 108 inches.
- D. Density: Type X, 1.30 pcf (21 kg/cu m), minimum.
- E. Water Absorption: Type X, 0.3 percent by volume, maximum, by total immersion.

2.06 JACKETING AND ACCESSORIES

- A. PVC Plastic.
 - 1. Manufacturers:
 - a. Johns Manville Corporation.
 - b. Substitutions: See Section 016000 - Product Requirements.

2. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: 0 degrees F.
 - b. Maximum Service Temperature: 150 degrees F.
 - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil, 0.010 inch.
 - e. Connections: Brush on welding adhesive.
3. Covering Adhesive Mastic: Compatible with insulation.
- B. Vapor Barrier Membranes: ASTM C1136, Type IX.
 1. Multilayer Laminate Vapor Barrier:
 - a. Thickness: 2.4 mil, 0.002 inch.
 - b. Moisture Vapor Permeability: 0.00 perm inch, when tested in accordance with ASTM E96/E96M.
 - c. Manufacturers:
 - 1) Polyguard Products; ZERO-PERM: www.polyguardproducts.com/#sle.
 - 2) Substitutions: See Section 016000 - Product Requirements.

2.07 ACCESSORIES

- A. General Requirements:
 1. Provide required accessories in accordance with and subject to the recommendations of the insulation manufacturer.
 2. Furnish compatible materials which do not contribute to corrosion, soften, or otherwise attack surfaces to which applied, in either the wet or dry state.
 3. Comply with ASTM C795 requirements for materials to be used on stainless steel surfaces.
 4. Supply materials that are asbestos free.
- B. Corrosion Inhibitors:
 1. Corrosion Control Gel:
 - a. Manufacturers:
 - 1) Polyguard Products; RG2400LT.
 - 2) Substitutions: See Section 016000 - Product Requirements.
 - b. Corrosion Protection: Comply with ASTM B117 and ASTM D610.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Test piping for design pressure, liquid tightness, and continuity prior to applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Exposed Piping: Locate insulation and cover seams in least visible locations.
- C. Insulated Pipes Conveying Fluids Below Ambient Temperature:
 1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- D. Glass Fiber Insulated Pipes Conveying Fluids Below Ambient Temperature:

1. Provide vapor barrier jackets, factory-applied or field-applied; secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- E. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- F. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- G. Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:
1. Provide standard jackets, with or without vapor barrier, factory-applied, or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure-sensitive adhesive. Secure with outward clinch expanding staples.
 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- H. Inserts and Shields:
1. Application: Piping 1-1/2 inches diameter or larger.
 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 3. Insert location: Between support shield and piping and under the finish jacket.
 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- I. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, see Section 078400.
- J. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with PVC jacket and fitting covers.
- K. Concealed Piping: Finish with fitting covers on flanges, fittings, valves, and specialties.
- L. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping. Provide two coats of UV-resistant finish for flexible elastomeric cellular insulation without jacketing.

3.03 SCHEDULE

- A. Heating Systems:
1. Heating Water Supply and Return:
 - a. NPS 1-1/4 and Smaller: 1-1/2 inch thick Rigid Glass Fiber.
 - b. NPS 1-1/2 and Larger: 2 inch thick Rigid Glass Fiber.
- B. Cooling Systems:
1. Cold Condensate Drains:
 - a. All Sizes: 1/2 inch thick Rigid Glass Fiber with Vapor Barrier.
 - b. All Sizes: 3/4 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
 2. Condensate Drains from Cooling Coils:
 - a. All Sizes: 1/2 inch thick Rigid Glass Fiber with Vapor Barrier.
 - b. All Sizes: 3/4 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
 3. Refrigerant Suction:

- a. All Sizes: 1-1/2 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
 - b. Provide aluminum jacketing for exposed exterior piping.
- 4. Refrigerant Hot Gas:
 - a. All Sizes: 1-1/2 inch thick Flexible Elastomeric Cellular with Vapor Barrier.
 - b. Provide aluminum jacketing for exposed exterior piping.
- 5. Refrigerant Liquid:
 - a. All Sizes: 1 inch thick Flexible Elastomeric Cellular.
 - b. Provide aluminum jacketing for exposed exterior piping.
- C. Outdoor Systems:
 - 1. Refrigerant Suction, Liquid and Hot Gas:
 - a. All Sizes: 2 inch thick Flexible Elastomeric Cellular with Vapor Barrier and Aluminum Jacket.

END OF SECTION 230719

**SECTION 230800
COMMISSIONING OF HVAC**

PART 1 GENERAL

1.01 SUMMARY

- A. See Section 019113 - General Commissioning Requirements for overall objectives; comply with the requirements of Section 019113.
- B. This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.
- C. The Commissioning Provider (CxP) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.
- D. The entire HVAC system is to be commissioned, including commissioning activities for the following specific items:
 - 1. Control system.
 - 2. Major and minor equipment items.
 - 3. Piping systems and equipment.
 - 4. Terminal units.
 - 5. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
- E. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

1.02 REFERENCE STANDARDS

- A. ASHRAE Guideline 1.1 - Application of the Commissioning Process to New HVAC&R Systems; 2025.

1.03 SUBMITTALS

- A. Updated Submittals: Keep Commissioning Provider (CxP) informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
- B. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Provider.
- C. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:
 - 1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.
 - 2. Full as-built set of control drawings.
 - 3. Full as-built sequence of operations for each piece of equipment.
 - 4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
 - a. Floor.
 - b. Room number.
 - c. Room name.

- d. Air handler unit ID.
- e. Reference drawing number.
- f. Air terminal unit tag ID.
- g. Heating and/or cooling valve tag ID.
- h. Minimum air flow rate.
- i. Maximum air flow rate.
5. Full print out of all schedules and set points after testing and acceptance of the system.
6. Full as-built print out of software program.
7. Electronic copy on disk of the entire program for this facility.
8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
10. Control equipment component submittals, parts lists, etc.
11. Warranty requirements.
12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
 - a. Sequences of operation.
 - b. Control drawings.
 - c. Points lists.
 - d. Controller and/or module data.
 - e. Thermostats and timers.
 - f. Sensors and DP switches.
 - g. Valves and valve actuators.
 - h. Dampers and damper actuators.
 - i. Program setups (software program printouts).
- D. Project Record Documents: See Section 017800 for additional requirements.
 1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
 2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.
- E. Draft Training Plan: In addition to requirements specified in Section 017900, include:
 1. Follow the recommendations of ASHRAE Guideline 1.1.
 2. Control system manufacturer's recommended training.
 3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.
- F. Training Manuals: See Section 017900 for additional requirements.
 1. Provide three extra copies of the controls training manuals in a separate manual from the O&M manuals.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

- A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.

- B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

PART 3 EXECUTION

3.01 PREPARATION

- A. Cooperate with CxP in development of the Prefunctional Checklists and Functional Test Procedures.
- B. Furnish additional information requested by CxP.
- C. Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for use by CxP; update the schedule as appropriate.
- D. Notify CxP when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction, notify ahead of time and be proactive in seeing that CxP has the scheduling information needed to efficiently execute the commissioning process.
- E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.
- F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.
- G. Provide temperature and pressure taps in accordance with Contract Documents.

3.02 INSPECTING AND TESTING - GENERAL

- A. Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.
- B. Perform the Functional Tests directed by CxP for each item of equipment or other assembly to be commissioned.
- C. Provide two-way radios for use during the testing.
- D. Valve/Damper Stroke Setup and Check:
 - 1. For all valve/damper actuator positions checked, verify the actual position against the control system readout.
 - 2. Set pump/fan to normal operating mode.
 - 3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
 - 4. Command valve/damper open; verify position is full open and adjust output signal as required.
 - 5. Command valve/damper to a few intermediate positions.
 - 6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
- E. Isolation Valve or System Valve Leak Check: For valves not by coils.
 - 1. With full pressure in the system, command valve closed.
 - 2. Use an ultra-sonic flow meter to detect flow or leakage.

- F. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.03 TAB COORDINATION

- A. TAB: Testing, adjusting, and balancing of HVAC.
- B. Coordinate commissioning schedule with TAB schedule.
- C. Review the TAB plan to determine the capabilities of the control system toward completing TAB.
- D. Provide all necessary unique instruments and instruct the TAB technicians in their use; such as handheld control system interface for setting terminal unit boxes, etc.
- E. Have all required Prefunctional Checklists, calibrations, startup, and component Functional Tests of the system completed and approved by CxP prior to starting TAB.
- F. Provide a qualified control system technician to operate the controls to assist the TAB technicians or provide sufficient training for the TAB technicians to operate the system without assistance.

3.04 CONTROL SYSTEM FUNCTIONAL TESTING

- A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of Contract Documents and the detailed Sequences of Operation documentation submittal.
- B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with Contract Documents.
- C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by CxP.
- D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
 - 1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
 - 2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.
- E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.
- F. Demonstrate the following to CxP during testing of controlled equipment; coordinate with commissioning of equipment.
 - 1. Setpoint changing features and functions.
 - 2. Sensor calibrations.
- G. Demonstrate to CxP:
 - 1. That all specified functions and features are set up, debugged and fully operable.
 - 2. That scheduling features are fully functional and setup, including holidays.
 - 3. That all graphic screens and value readouts are completed.
 - 4. Correct date and time setting in central computer.

5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
 6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to Owner.
 7. Power failure and battery backup and power-up restart functions.
 8. Global commands features.
 9. Security and access codes.
 10. Occupant over-rides (manual, telephone, key, keypad, etc.).
 11. O&M schedules and alarms.
 12. Occupancy sensors and controls.
 13. All control strategies and sequences not tested during controlled equipment testing.
- H. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to Owner.

3.05 OPERATION AND MAINTENANCE MANUALS

- A. See Section 017800 for additional requirements.
- B. Add design intent documentation furnished by Architect to manuals prior to submission to Owner.
- C. Submit manuals related to items that were commissioned to Commissioning Provider for review; make changes recommended by Commissioning Provider.
- D. Commissioning Provider will add commissioning records to manuals after submission to Owner.

3.06 DEMONSTRATION AND TRAINING

- A. See Section 017900 for additional requirements.
- B. Demonstrate operation and maintenance of HVAC system to Owner' personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.
- C. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to CxP during Functional Testing.
- D. Provide classroom and hands-on training of Owner's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned. Provide the following minimum durations of training:
 1. Boilers and System: 2 hours.
 2. Air Handling Units: 2 hours.
 3. Variable Speed Drives: 2 hours.
 4. Air Terminal Units: 2 hours.
 5. Packaged Rooftop Units: 8 hours.
 6. Split System AC or Heat Pumps: 8 hours.

- E. TAB Review: Instruct Owner's personnel for minimum 2 hours, after completion of TAB, on the following:
 - 1. Review final TAB report, explaining the layout and meanings of each data type.
 - 2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
 - 3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
 - 4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
 - 5. Other salient information that may be useful for facility operations, relative to TAB.
- F. HVAC Control System Training: Perform training in at least three phases:
 - 1. Phase 1 - Basic Control System: Provide minimum of 8 hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
 - a. This training may be held on-site or at the manufacturer's facility.
 - b. If held off-site, the training may occur prior to final completion of the system installation.
 - c. For off-site training, Contractor shall pay expenses of up to two attendees.
 - 2. Phase 2 - Integrating with HVAC Systems: Provide minimum of 8 hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
 - a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
 - b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
 - c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends; provide practice in setting up trend logging and monitoring during training session.
 - d. Every display screen, allowing time for questions.
 - e. Point database entry and modifications.
 - 3. Phase 3 - Post-Occupancy: Six months after occupancy conduct minimum of 4 hours of training. Tailor training session to questions and topics solicited beforehand from Owner. Also be prepared to address topics brought up and answer questions concerning operation of the system.
- G. Provide the services of manufacturer representatives to assist instructors where necessary.
- H. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

END OF SECTION 230800

**SECTION 230913
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Control panels.
- B. Control Valves:
 - 1. Ball valves with factory-mounted actuators.
 - 2. Globe valves with factory-mounted actuators.
 - 3. Butterfly valves with factory-mounted actuators.
 - 4. Electronic valve operators.
- C. Dampers.
- D. Damper Operators:
 - 1. Electric operators.
- E. Wall-, Surface-, and Duct-Mounted Sensors:
 - 1. Temperature sensors.
 - 2. Humidity sensors.
 - 3. Building static pressure transmitters.
 - 4. Static air pressure sensors.
 - 5. Air pressure transmitters.
 - 6. Airflow meters; thermal dispersion.
 - 7. Damper position indicators.
 - 8. Nitrogen dioxide sensors.
 - 9. Carbon monoxide sensors.
 - 10. Carbon dioxide sensors.
- F. Thermostats:
 - 1. Electric thermostats.
 - 2. Freezestats.
 - 3. Room-mount thermostat accessories.
 - 4. Outdoor-reset thermostats.
- G. Fan and pump motor run-status monitoring.

1.02 RELATED REQUIREMENTS

- A. Section 230519 - Meters and Gauges for HVAC Piping: Thermometer sockets and gauge taps.
- B. Section 232113 - Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, and gauge taps.
- C. Section 232114 - Hydronic Specialties.
- D. Section 233300 - Air Duct Accessories.
- E. Section 253513 - Integrated Automation Actuators and Operators.
- F. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.
- G. Section 262726 - Wiring Devices: Elevation of exposed components.

1.03 REFERENCE STANDARDS

- A. ANSI/FCI 70-2 - Control Valve Seat Leakage; 2021.

- B. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2026).
- C. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code); 1989 (Corrigendum 2019).
- D. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- E. NEMA BS 31032 - Residential Controls—Electrical Wall-Mounted Room Thermostats; 2025.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.
- C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.
- D. Manufacturer's Instructions: Provide for all manufactured components.
- E. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum 5 years documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years experience approved by manufacturer.

1.06 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Correct defective work within a five year period after Substantial Completion.

PART 2 PRODUCTS**2.01 EQUIPMENT - GENERAL**

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

2.02 CONTROL PANELS

- A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.
- B. NEMA EN 10250, general purpose utility enclosures with enameled finished face panel.
- C. Provide common keying for all panels.

2.03 CONTROL VALVES

- A. Segemented and Characterized Ball Valves with Factory-Mounted Actuators:
 - 1. Service: Use for hot water.

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2. Flow Characteristic: Fully proportioning, equal percentage.
 3. Rangeability: 500 to 1.
 4. Leakage: Tested in accordance with ANSI/FCI 70-2.
 - a. Straight-Through Flow on 2-Way and 3-Way Valves: Class IV.
 - b. Bypass Flow on 3-Way Valves: Class III.
 5. Service Temperature Range: Minus 20 to 250 degrees F.
 6. Valve Body:
 - a. Under 2-1/2 inches:
 - 1) Connection: NPT.
 - 2) Pressure Rating: 400 psi.
 - 3) Materials:
 - (a) Body: Brass.
 - (b) Ball: Chrome-plated brass.
 - (c) Stem: 300 series stainless steel.
 - (d) Seat: Graphite-reinforced PTFE with EPDM O-Ring backing.
 - (e) Stem Seal: EPDM O-Rings.
 - (f) Flow Control Disk: Thermoplastic synthetic-resin.
 - b. 2-1/2 inches and Above:
 - 1) Connection Type: Flanged.
 - 2) ANSI Rating: Class 125 or 150.
 - 3) Materials:
 - (a) Body: Manufactured from brass with ductile iron flanges, cast iron, carbon steel, or stainless steel.
 - (b) Ball: 300 series stainless steel.
 - (c) Stem: 300 series stainless steel.
 - (d) Seat: Graphite-reinforced PTFE with EPDM O-Ring backing.
 - (e) Stem Seal: EPDM O-Rings.
 - (f) Flow Control Disk: Thermoplastic synthetic-resin.
 - c. Service Temperature:
 7. Hydronic Systems: Size for 3 psig maximum pressure drop at design flow rate.
 8. Actuator Requirements:
 - a. Assembly: Factory-mounted.
 - b. Input: 0 to 5 VDC configured for proportional control.
 - c. Accessories: Provide with valve position indicator and manual override.
 - B. Globe Valves with Factory-Mounted Actuators:
 1. Up to 2 inches: Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.
 2. Over 2 inches: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
 3. Hydronic Systems:
 - a. Rate for service pressure of 125 psig at 250 degrees F.
 - b. Size for 3 psig maximum pressure drop at design flow rate.
 - c. Provide two-way valves with equal percentage characteristics and three-way valves with linear characteristics. Size two-way valve operators to close valves against pump shut-off head.
 - C. Butterfly Valves with Factory-Mount Actuators:
-

1. Iron body, bronze disc, resilient replaceable seat for service to 180 degrees F wafer or lug ends, extended neck.
2. Hydronic Systems:
 - a. Rate for service pressure of 125 psig at 250 degrees F.
 - b. Size for 1 psig maximum pressure drop at design flow rate.
- D. Electronic Valve Actuators:
 1. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.
 2. Select operator for full shut-off at maximum pump differential pressure.

2.04 DAMPERS

- A. See Section 233300 for dampers and this section for actuators and operators.

2.05 DAMPER OPERATORS

- A. General:
 1. Provide actuators with torque capacity sized for minimum of 20 percent greater than maximum design stream velocity and hold tight seal against maximum system pressures.
 2. Provide spring return for two position control and for fail safe operation.
 3. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.
 4. Provide one operator for maximum 36 sq ft damper section.
 5. See Section 253513 for field-mount damper actuators and operators.
- B. Electric Operators:
 1. Spring return, adjustable stroke motor having oil immersed gear train, with auxiliary end switch.

2.06 WALL-, SURFACE-, AND DUCT-MOUNT SENSORS

- A. Temperature Sensors:
 1. Use thermistor or RTD type temperature sensing elements with characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy.
 2. Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F.
 3. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
 4. Temperature Sensing Device: Compatible with project DDC controllers.
 5. Performance Characteristics:
 - a. RTD:
 - 1) Room Sensor Accuracy: Plus/minus 0.50 degrees F minimum.
 - 2) Duct Averaging Accuracy: Plus/minus 0.50 degrees F minimum.
 - 3) Chilled Water Accuracy: Plus/minus 0.50 degrees F minimum.
 - 4) All Other Accuracy: Plus/minus 0.75 degrees F minimum.
 - 5) Range: Minus 40 degrees F through 220 degrees F minimum.
 - b. Thermistor:
 - 1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
 - 2) Range: Minus 25 degrees F through 122 degrees F minimum.
 - 3) Heat Dissipation Constant: 2.7 mW per degree C.
 - c. Temperature Transmitter:
 - 1) Accuracy: 0.10 degree F minimum or plus/minus 0.20 percent of span.
 - 2) Output: 4 to 20 mA.

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- d. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
 - e. Immersion Temperature Sensors: A sensor encased in a corrosion-resistant probe with an indoor junction box service entry body.
 - f. Room Temperature Sensors:
 - 1) Construct for surface or wall box mounting.
 - 2) Stainless steel cover plate with insulated back.
 - g. Temperature Averaging Elements:
 - 1) Use on duct sensors for ductwork 10 sq ft or larger.
 - 2) Use averaging elements where prone to stratification with sensor length 8 ft or 16 ft.
 - 3) Provide for all mixed air and heating coil discharge sensors regardless of duct size.
 - h. Insertion Elements:
 - 1) Use in ducts not affected by temperature stratification or smaller than 11 sq inches.
 - 2) Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches.
- B. Humidity Sensors, Duct-Mounted:
- 1. Digitally profiled thin-film capacitive sensor probe extended from die-cast metal, weather-proof plastic or metal housing designed for duct mounting.
 - 2. Measuring Scale: 0 to 100 percent RH, noncondensing, temperature compensated.
 - 3. Hardwired Output: Two-wire, 4 to 20 mA, loop powered.
 - 4. Accuracy: Plus/minus 1 percent between 20 to 40 percent RH linear range, NIST traceable with multi-point calibration.
- C. Building Static Pressure Transmitters:
- 1. Single port for direct or tubing connection into wall or ceiling static pressure tap, direct acting, double bell, scale range 0.01 to 6.0 in-wc positive or negative, and sensitivity of 0.0005 in-wc. Transmit electronic signal to receiver with matching scale range.
- D. Static-Air Pressure Sensors:
- 1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
 - 2. Temperature compensate with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F.
 - 3. Accuracy: One percent of full scale with repeatability 0.3 percent.
 - 4. Output: 0 to 5 vdc with power at 12 to 28 vdc.
- E. Air Pressure Transmitters:
- 1. General: Provide dry air media, differential pressure transducers to monitor duct and room pressure.
 - 2. Accuracy: Plus/minus 2 percent full scale of range with combined linearity and hysteresis.
 - 3. Zero Adjust: Pushbutton auto-zero and digital input using 2-position terminal block.
 - 4. Measuring Range: 1 to 10 in-wc, unidirectional or bidirectional.
 - 5. Hardwired Output: 2-wire, loop-powered 4 to 20 mA, field selectable.
- F. Airflow Meters; Thermal Dispersion:
- 1. Manufacturers:
 - a. Air Monitor, a brand of Onicon, Inc; ELECTRA-Flo Series: www.onicon.com/#sle.
 - b. Ebtron, Inc: www.ebtron.com/#sle.
 - c. Greystone Energy Systems, Inc: www.greystoneenergy.com/#sle.
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- d. Ruskin Company: www.ruskin.com/#sle.
 - 2. Configuration: Duct or plenum inserted assembly using up to eight water-resistant thermal dispersion sensors per metal probe wired into external access box holding self-diagnosing sensor interface electronics with respective field wire and cable landing terminals.
 - 3. Provide thermal dispersion flow meters complete with matched transducers, self aligning installation hardware, and transducer cables.
 - 4. Optimize thermal dispersion transducer for the specific duct or pipe and process conditions for the application.
 - 5. Signal Monitoring Range:
 - a. Air Velocity: 0 to 2000 fpm, bidirectional converted to airflow using section area and air velocity from listed range.
 - b. Temperature: 32 to 104 degrees F.
 - 6. Accuracy: Plus or minus 1 percent, NIST with a plus or minus 0.25 percent repeatability over listed range. Include means to zero, adjust, and calibrate outputs.
 - 7. Access Box: NEMA EN 10250, Type 1 with hinged cover housing and cable access ports.
 - 8. Outputs: Two-wire, 4 to 20 mA, for each measured signal, configurable.
 - 9. BAS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet MS/TP.
 - G. Damper Position Indicators: Potentiometer mounted in enclosure with adjustable crank arm assembly connected to damper to transmit 0 to 100 percent damper travel.
 - H. Nitrogen Dioxide Sensors:
 - 1. Gas sensing module that holds fixed or replaceable nitrogen dioxide gas-sensor cartridge.
 - 2. Form Factor: IEC 60529, IP20 enclosure, single-gang electrical box mounted.
 - 3. Electromechanical sensor with 0 to 15 ppm measurement range.
 - 4. Accuracy: Plus/minus Five percent of range with 0.1 ppm resolution.
 - 5. Hardwired Output: Three-wire, 4 to 20 mA, loop powered.
 - 6. Alarm: Auxiliary dry contact relay driven by setpoint adjustable between 1 to 180 ppm.
 - I. Carbon Monoxide Sensors:
 - 1. Gas sensing module that holds fixed or replaceable carbon monoxide gas-sensor cartridge.
 - 2. Form Factor: IEC 60529, IP20 enclosure, single-gang electrical box mounted.
 - 3. Electromechanical sensor with 0 to 500 ppm measurement range.
 - 4. Accuracy: Plus/minus Five percent of range with 1 ppm resolution.
 - 5. Hardwired Output: Three-wire, 4 to 20 mA, loop powered.
 - 6. Alarm: Auxiliary dry contact relay driven by setpoint adjustable between 25 to 180 ppm.
 - J. Carbon Dioxide Sensors, Duct and Wall:
 - 1. General: Provide nondispersive infrared (NDIR), diffusion sampling CO2 sensors with integral transducers and linear output.
 - 2. Air Temperature: Range of 32 to 122 degrees F.
 - 3. Relative Humidity: Range of 0 to 95 percent (noncondensing).
 - 4. Calibration Characteristics:
 - a. Automatically compensating algorithm for sensor drift due to sensor degradation.
 - b. Maximum Drift: 2 percent.
 - c. User calibratable with a minimum calibration interval of 5 years.
 - 5. Construction:
 - a. Sensor Chamber: Noncorrosive material for neutral effect on carbon dioxide sample.
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- b. Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.
- c. Housing: High impact plastic.

2.07 THERMOSTATS

- A. Electric Thermostats:
 - 1. Type: NEMA BS 31032, 24 volts, with setback/setup temperature control.
 - 2. Service: Cooling only.
 - 3. Covers: Locking with set point adjustment, with thermometer.
- B. Freezestats:
 - 1. Configuration: Vapor-filled capillary.
 - 2. Probe Sensing Length: 20 feet.
 - 3. Setpoint Adjust Control: Screw with manual reset switch.
 - 4. Switch Type: SPDT, snap-action, form C in dust-protected enclosure.
 - 5. Mounting: Locate on cooling coil intake side.
 - 6. Field Interface: Connect load line-voltage to starter.
 - 7. Electrical Rating: As indicated on drawings.
- C. Room-Mounted Thermostat Accessories:
 - 1. Thermostat Covers: Brushed aluminum.
 - 2. Insulating Bases: For thermostats located on exterior walls.
- D. Outdoor Reset Thermostats:
 - 1. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.
 - 2. Scale range: Minus 10 to 70 degrees F.

2.08 FAN AND PUMP MOTOR RUN-STATUS MONITORING

- A. Current Switches:
 - 1. Mini Solid-Core: 2-State, On/Off digital output of motor status with adjustable trip point to detect belt loss or mechanical failure.
 - 2. Mini Split-Core: 2-state, On/Off digital output of inverter-duty motor status with adjustable trip point to detect belt loss or mechanical failure.
 - 3. Maximum AC Current Monitoring Value: 175 percent of rated motor current.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that systems are ready to receive work.
- C. Beginning of installation means installer accepts existing conditions.
- D. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.
- E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- F. Ensure installation of components is complementary to installation of similar components.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.

- B. Check and verify location of thermostats with plans and room details before installation. Locate 60 inches above floor. Align with lighting switches and humidistats; see Section 262726.
- C. Mount freeze protection thermostats using flanges and element holders.
- D. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
- E. Provide separable sockets for liquids and flanges for air bulb elements.
- F. Provide guards on thermostats in entrances.
- G. Provide valves with position indicators and with pilot positioners where sequenced with other controls.
- H. Provide mixing dampers of opposed blade construction arranged to mix streams. Provide pilot positioners on mixed air damper motors.
- I. Provide isolation (two-position) dampers of parallel blade construction.
- J. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
- K. Mount control panels adjacent to associated equipment on vibration free walls or free-standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
- L. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- M. Provide conduit and electrical wiring in accordance with Section 260583. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

3.03 MAINTENANCE

- A. See Section 017000 - Execution and Closeout Requirements for additional requirements relating to maintenance service.
- B. Provide service and maintenance of control system for one year from Date of Substantial Completion.
- C. Provide complete service of controls systems, including call backs, and submit written report of each service call.

END OF SECTION 230913

**SECTION 230923
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. System description.
- B. Controllers.
- C. Power supplies and line filtering.
- D. System software.
- E. Controller software.
- F. HVAC control programs.

1.02 RELATED REQUIREMENTS

- A. Section 230913 - Instrumentation and Control Devices for HVAC.
- B. Section 230993 - Sequence of Operations for HVAC Controls.

1.03 REFERENCE STANDARDS

- A. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests; 2019h, with Editorial Revision (2022).
- B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. UL (DIR) - Online Certifications Directory; Current Edition.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for each system component and software module.
- C. Shop Drawings:
 - 1. Indicate trunk cable schematic showing programmable control unit locations, and trunk data conductors.
 - 2. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration digital media containing graphics.
 - 3. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
 - 4. Indicate description and sequence of operation of operating, user, and application software.
- D. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.
- E. Operation and Maintenance Data:
 - 1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
 - 2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
 - 3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

- F. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

- A. Perform work in accordance with NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum 5 years of documented experience.
- C. Installer Qualifications: Company specializing in performing work of the type specified and with minimum 5 years of documented experience.
- D. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for purpose specified and indicated.

1.06 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Correct defective Work within a five year period after Substantial Completion.
- C. Provide five year manufacturer's warranty for field programmable micro-processor based units.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Schneider Electric: www.schneider-electric.us/#sle.
- B. Substitutions: See Section 016000 - Product Requirements.

2.02 SYSTEM DESCRIPTION

- A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units.
- B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
- C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
- D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 230913.
- E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- F. Controls shall be integrated into existing TBS Controls / Stark Tech controls system.
- G. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

2.03 TEMPERATURE CONTROL AND INSTRUMENTATION FOR HVAC

- A. For purposes of this specification, the Building Automation System (BAS) manufacturer shall be defined as the BAS equipment manufacturer or the BAS equipment manufacturer's authorized dealer or branch office.
- B. All new controls installed in this project shall be an extension of the existing TBS Controls / Stark Tech control system.

- C. All analog and binary inputs and outputs (points) shown on H Series drawings or described in Section 230993 "Sequence of Operations for HVAC Controls" are considered a requirement of Division 23 and are to be provided by this contractor. All points are to be provided whether provided through manufacturer provided controllers, through the Building Automation System (BAS) or a combination of both. If equipment is being controlled by manufacturer controllers and a point(s) is not provided through the manufacturer controller, that point(s) shall be provided through the BAS system. All points are required to be integrated into the BAS, with full functionality by the end user, regardless of source. The BAS provider shall be responsible for the integration and functionality of all points. All points are also required to be shown in final system graphics.
- D. The Building Automation System (BAS) manufacturer shall furnish and install direct digital control (DDC) controls fully integrated into the Owners existing Building Automation System. The controls shall incorporate DDC for energy management, equipment monitoring, control, and subsystems as herein specified. All new equipment shall be controlled by the BAS system. The installing manufacturer shall certify in writing, that the equipment manufacturer has prepared the shop drawings and that the equipment manufacturer has supervised their installation. In addition, the equipment manufacturer shall certify, in writing, that their company prepared the shop drawings and that all temperature control equipment was installed under their direct supervision.
- E. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed especially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.
- F. The BAS manufacturer shall be responsible for all BAS and Temperature Control wiring for a complete and operable system. All wiring shall be done in accordance with all local and national codes.
- G. The new controls being provided as part of this project must be completely compatible in all respects with the existing HVAC systems and equipment that are currently installed. It shall be the responsibility of the temperature controls contractor to meet the requirements of Sections 230913 "Instrumentation and Control Devices for HVAC", 230923 "Direct-Digital Control System for HVAC", 230993 "Sequence of Operations for HVAC Controls", and all H Series drawings with respect to controls, control components and control sequences.
- H. The removal of any existing component (not to be re-used) shall include the removal of all associated wiring, conduit and support attachments. Where existing-to-remain finishes are damaged as a result of the removal of any existing control equipment or where the removal exposes a previously damaged finish, the contractor shall repair the finish to match existing.

2.04 CONTROLLERS

- A. Building Controllers:
 - 1. General:
 - a. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
 - b. Provide sufficient memory to support controller's operating system, database, and programming requirements.
 - c. Share data between networked controllers.
 - d. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
 - e. Utilize real-time clock for scheduling.

- f. Continuously check processor status and memory circuits for abnormal operation.
 - g. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
 - h. Communication with other network devices to be based on assigned protocol.
 - 2. Communication:
 - a. Controller to reside on a BACnet network using ISO 8802-3 (ETHERNET) Data Link/Physical layer protocol.
 - b. Perform routing when connected to a network of custom application and application specific controllers.
 - c. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
 - 3. Anticipated Environmental Ambient Conditions:
 - a. Outdoors and/or in Wet Ambient Conditions:
 - 1) Mount within waterproof enclosures.
 - 2) Rated for operation at 40 to 150 degrees F.
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.
 - 4. Provisions for Serviceability:
 - a. Diagnostic LEDs for power, communication, and processor.
 - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
 - 5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
 - 6. Power and Noise Immunity:
 - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
 - b. Perform orderly shutdown below 80 percent of nominal voltage.
 - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.
- B. Custom Application Controller:
 - 1. General:
 - a. Provide sufficient memory to support controller's operating system, database, and programming requirements.
 - b. Share data between networked, microprocessor based controllers.
 - c. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
 - d. Utilize real-time clock for scheduling.
 - e. Continuously check processor status and memory circuits for abnormal operation.
 - f. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
 - g. Communication with other network devices to be based on assigned protocol.
 - 2. Communication:
 - a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
 - b. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.

3. Anticipated Environmental Ambient Conditions:
 - a. Outdoors and/or in Wet Ambient Conditions:
 - 1) Mount within waterproof enclosures.
 - 2) Rated for operation at 40 to 150 degrees F.
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.
 4. Provisions for Serviceability:
 - a. Diagnostic LED's for power, communication, and processor.
 - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
 5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
 6. Power and Noise Immunity:
 - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
 - b. Perform orderly shutdown below 80 percent of nominal voltage.
 - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.
- C. Application Specific Controllers:
1. General:
 - a. Not fully user programmable, microprocessor based controllers dedicated to control specific equipment.
 - b. Customized for operation within the confines of equipment served.
 - c. Communication with other network devices to be based on assigned protocol.
 2. Communication:
 - a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
 - b. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
 3. Anticipated Environmental Ambient Conditions:
 - a. Outdoors and/or in Wet Ambient Conditions:
 - 1) Mount within waterproof enclosures.
 - 2) Rated for operation at 40 to 150 degrees F.
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.
 4. Provisions for Serviceability:
 - a. Diagnostic LEDs for power, communication, and processor.
 - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
 5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
 6. Power and Noise Immunity:
 - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
 - b. Perform orderly shutdown below 80 percent of nominal voltage.
 - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 3 feet.
-

D. Input/Output Interface:

1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.
2. All Input/Output Points:
 - a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
 - b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
3. Binary Inputs:
 - a. Allow monitoring of On/Off signals from remote devices.
 - b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
 - c. Sense dry contact closure with power provided only by the controller.
4. Pulse Accumulation Input Objects: Comply with all requirements of binary input objects and accept up to 10 pulses per second.
5. Analog Inputs:
 - a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
 - b. Compatible with and field configurable to commonly available sensing devices.
6. Binary Outputs:
 - a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
 - b. Outputs provided with three position (On/Off/Auto) override switches.
 - c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.
7. Analog Outputs:
 - a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
 - b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
 - c. Drift to not exceed 0.4 percent of range per year.
8. Tri State Outputs:
 - a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
 - b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
 - c. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
9. System Object Capacity:
 - a. System size to be expandable to twice the number of input output objects required by providing additional controllers, including associated devices and wiring.
 - b. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

2.05 POWER SUPPLIES AND LINE FILTERING**A. Power Supplies:**

1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
 2. Limit connected loads to 80 percent of rated capacity.
 3. Match DC power supply to current output and voltage requirements.
 4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
 5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
 6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
 7. Operational Ambient Conditions: 32 to 120 degrees F.
 8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD-810 for shock and vibration.
 9. Line voltage units UL recognized and CSA approved.
- B. Power Line Filtering:
1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
 2. Minimum surge protection attributes:
 - a. Dielectric strength of 1000 volts minimum.
 - b. Response time of 10 nanoseconds or less.
 - c. Transverse mode noise attenuation of 65 dB or greater.
 - d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

2.06 SYSTEM SOFTWARE

- A. Operating System:
1. Concurrent, multi-tasking capability.
 - a. Common Software Applications Supported: Microsoft Excel.
 - b. Acceptable Operating Systems: _____.
 2. System Graphics:
 - a. Allow up to 10 graphic screens, simultaneously displayed for comparison and monitoring of system status.
 - b. Animation displayed by shifting image files based on object status.
 - c. Provide method for operator with password to perform the following:
 - 1) Move between, change size, and change location of graphic displays.
 - 2) Modify on-line.
 - 3) Add, delete, or change dynamic objects consisting of:
 - (a) Analog and binary values.
 - (b) Dynamic text.
 - (c) Static text.
 - (d) Animation files.
 3. Custom Graphics Generation Package:
 - a. Create, modify, and save graphic files and visio format graphics in PCX formats.
 - b. HTML graphics to support web browser compatible formats.
 - c. Capture or convert graphics from AutoCAD.
 4. Standard HVAC Graphics Library:
 - a. HVAC Equipment:
 - 1) Boilers.

- 2) Air Handlers.
 - 3) Terminal HVAC Units.
 - 4) Fan Coil Units.
 - 5) Unit Ventilators.
 - b. Ancillary Equipment:
 - 1) Fans.
 - 2) Pumps.
 - 3) Coils.
 - 4) Valves.
 - 5) Piping.
 - 6) Dampers.
 - 7) Ductwork.
- B. Workstation System Applications:
- 1. Automatic System Database Save and Restore Functions:
 - a. Current database copy of each Building Controller is automatically stored on hard disk.
 - b. Automatic update occurs upon change in any system panel.
 - c. In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.
 - 2. Manual System Database Save and Restore Functions by Operator with Password Clearance:
 - a. Save database from any system panel.
 - b. Clear a panel database.
 - c. Initiate a download of a specified database to any system panel.
 - 3. Software provided allows system configuration and future changes or additions by operators under proper password protection.
 - 4. On-line Help:
 - a. Context-sensitive system assists operator in operation and editing.
 - b. Available for all applications.
 - c. Relevant screen data provided for particular screen display.
 - d. Additional help available via hypertext.
 - 5. Security:
 - a. Operator log-on requires user name and password to view, edit, add, or delete data.
 - b. System security selectable for each operator.
 - c. System supervisor sets passwords and security levels for all other operators.
 - d. Operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
 - e. Automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
 - f. All system security data stored in encrypted format.
 - 6. System Diagnostics:
 - a. Operations Automatically Monitored:
 - 1) Workstations.
 - 2) Printers.
 - 3) Modems.
 - 4) Network connections.
-

- 5) Building management panels.
 - 6) Controllers.
- b. Device failure is annunciated to the operator.
- 7. Alarm Processing:
 - a. All system objects are configurable to "alarm in" and "alarm out" of normal state.
 - b. Configurable Objects:
 - 1) Alarm limits.
 - 2) Alarm limit differentials.
 - 3) States.
 - 4) Reactions for each object.
- 8. Alarm Messages:
 - a. Descriptor: English language.
 - b. Recognizable Features:
 - 1) Source.
 - 2) Location.
 - 3) Nature.
- 9. Configurable Alarm Reactions by Workstation and Time of Day:
 - a. Logging.
 - b. Printing.
 - c. Starting programs.
 - d. Displaying messages.
 - e. Dialing out to remote locations.
 - f. Paging.
 - g. Providing audible annunciation.
 - h. Displaying specific system graphics.
- 10. Custom Trend Logs:
 - a. Definable for any data object in the system including interval, start time, and stop time.
 - b. Trend Data:
 - 1) Sampled and stored on the building controller panel.
 - 2) Archivable on hard disk.
 - 3) Retrievable for use in reports, spreadsheets and standard database programs.
 - 4) Archival on LAN accessible storage media including hard disk, tape, Raid array drive, and virtual cloud environment.
 - 5) Protected and encrypted format to prevent manipulation, or editing of historical data and event logs.
- 11. Alarm and Event Log:
 - a. View all system alarms and change of states from any system location.
 - b. Events listed chronologically.
 - c. Operator with proper security acknowledges and clears alarms.
 - d. Alarms not cleared by operator are archived to the workstation hard disk.
- 12. Object, Property Status and Control:
 - a. Provide a method to view, edit if applicable, the status of any object and property in the system.
 - b. Status Available by the Following Methods:
 - 1) Menu.
 - 2) Graphics.

- 3) Custom Programs.
- 13. Reports and Logs:
 - a. Reporting Package:
 - 1) Allows operator to select, modify, or create reports.
 - 2) Definable as to data content, format, interval, and date.
 - 3) Archivable to hard disk.
 - b. Real-time logs available by type or status such as alarm, lockout, normal, etc.
 - c. Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
 - d. Set to be printed on operator command or specific time(s).
- 14. Reports:
 - a. Standard:
 - 1) Objects with current values.
 - 2) Current alarms not locked out.
 - 3) Disabled and overridden objects, points and SNVTs.
 - 4) Objects in manual or automatic alarm lockout.
 - 5) Objects in alarm lockout currently in alarm.
 - 6) Logs:
 - (a) Alarm History.
 - (b) System messages.
 - (c) System events.
 - (d) Trends.
 - b. Custom:
 - 1) Daily.
 - 2) Weekly.
 - 3) Monthly.
 - 4) Annual.
 - 5) Time and date stamped.
 - 6) Title.
 - 7) Facility name.
 - c. Tenant Override:
 - 1) Monthly report showing total, requested, after-hours HVAC and lighting services on a daily basis for each tenant.
 - 2) Annual report showing override usage on a monthly basis.
 - d. Electrical, Fuel, and Weather:
 - 1) Electrical Meter(s):
 - (a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - (b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.
 - 2) Fuel Meter(s):
 - (a) Monthly showing daily natural gas consumption for each meter.
 - (b) Annual summary showing monthly consumption for each meter.
 - 3) Weather:
 - (a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.

C. Workstation Applications Editors:

1. Provide editing software for each system application at PC workstation.
2. Downloaded application is executed at controller panel.
3. Full screen editor for each application allows operator to view and change:
 - a. Configuration.
 - b. Name.
 - c. Control parameters.
 - d. Set-points.
4. Scheduling:
 - a. Monthly calendar indicates schedules, holidays, and exceptions.
 - b. Allows several related objects to be scheduled and copied to other objects or dates.
 - c. Start and stop times adjustable from master schedule.
5. Custom Application Programming:
 - a. Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.
 - b. Programming Features:
 - 1) English oriented language, based on BASIC, FORTRAN, C, or PASCAL syntax allowing for free form programming.
 - 2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
 - 3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
 - 4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
 - 5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.
 - 6) Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
 - 7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.
 - 8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values can be used in IF/THEN comparisons, calculations, programming statement logic, etc.
 - 9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

2.07 CONTROLLER SOFTWARE

- A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.
 - B. System Security:
 1. User access secured via user passwords and user names.
 2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
 3. User Log On/Log Off attempts are recorded.
 4. Automatic Log Off occurs following the last keystroke after a user defined delay time.
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- C. Object or Object Group Scheduling:
 - 1. Weekly Schedules Based on Separate, Daily Schedules:
 - a. Include start, stop, optimal stop, and night economizer.
 - b. 10 events maximum per schedule.
 - c. Start/stop times adjustable for each group object.
 - 2. Holiday or Special Schedules:
 - a. Capability to define up to 99 schedules.
 - b. Repeated annually.
 - c. Length of each period is operator defined.
- D. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.
- E. Alarms:
 - 1. Binary object is set to alarm based on the operator specified state.
 - 2. Analog object to have high/low alarm limits.
 - 3. All alarming is capable of being automatically and manually disabled.
 - 4. Alarm Reporting:
 - a. Operator determines action to be taken for alarm event.
 - b. Alarms to be routed to appropriate workstation.
- F. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.
- G. Sequencing: Application software based upon specified sequences of operation in Section 230993.
- H. PID Control Characteristics:
 - 1. Direct or reverse action.
 - 2. Anti-windup.
 - 3. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
 - 4. User selectable controlled variable, set-point, and PED gains.
- I. Staggered Start Application:
 - 1. Prevents all controlled equipment from simultaneously restarting after power outage.
 - 2. Order of equipment startup is user selectable.
- J. Energy Calculations:
 - 1. Accumulated instantaneous power or flow rates are converted to energy use data.
 - 2. Algorithm calculates a rolling average and allows window of time to be user specified in minute intervals.
 - 3. Algorithm calculates a fixed window average with a digital input signal from a utility meter defining the start of the window period that in turn synchronizes the fixed-window average with that used by the power company.
- K. Anti-Short Cycling:
 - 1. All binary output objects protected from short-cycling.
 - 2. Allows minimum on-time and off-time to be selected.
- L. On-Off Control with Differential:
 - 1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
 - 2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.
- M. Run-Time Totalization:

1. Totalize run-times for all binary input objects.
2. Provides operator with capability to assign high run-time alarm.

2.08 HVAC CONTROL PROGRAMS

- A. Optimal Run Time:
 1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
 2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room temperature.
 3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
 4. Use outside air temperature to determine early shut down with ventilation override.
 5. Control Summary:
 - a. HVAC Control system begin/end status.
 - b. Optimal run time lock/unlock control status.
 - c. Heating/cooling mode status.
 - d. Optimal run time schedule.
 - e. Start/Stop times.
 - f. Occupancy and vacancy times.
 6. HVAC point summary:
 - a. Control system identifier and status.
 - b. Point ID and status.
 - c. Outside air temperature point ID and status.
 - d. Calculated optimal start and stop times.
- B. Supply Air Reset:
 1. Monitor heating and cooling loads in building spaces, terminal reheat systems, and single zone unit discharge temperatures.
 2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
 - a. Raising cooling temperatures to highest possible value.
 - b. Reducing heating temperatures to lowest possible level.
 3. Control summary:
 - a. HVAC control system status (begin/end).
 - b. Supply air reset system status.
 - c. Optimal run time system status.
 - d. High/low limits.
 - e. Deadband.
- C. Enthalpy Switchover:
 1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.
 2. Operator commands:
 - a. Add/delete fan status point.
 - b. Add/delete outside air temperature point.
 - c. Add/delete discharge controller point.
 - d. Define discharge controller parameters.
 - e. Add/delete return air temperature point.
 - f. Add/delete outside air dew point/humidity point.
 - g. Add/delete return air dew point/humidity point.

- h. Add/delete damper switch.
 - i. Add/delete minimum outside air.
 - j. Add/delete heating override switch.
 - k. Add/delete air flow rate.
 - l. Define enthalpy deadband.
 - m. Request HVAC point summary.
- 3. Control summary:
 - a. HVAC control system begin/end status.
 - b. Enthalpy switchover optimal system status.
 - c. Optimal return time system status.
 - d. Current outside air enthalpy.
 - e. Calculated mixed air enthalpy.
 - f. Calculated cooling coil enthalpy using outside air.
 - g. Calculated cooling coil enthalpy using mixed air.
 - h. Calculated enthalpy difference.
 - i. Enthalpy switchover deadband.
 - j. Status of damper mode switch.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.02 INSTALLATION

- A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
- B. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 230993.
- C. Provide conduit and electrical wiring in accordance with Section 260583. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

3.03 MANUFACTURER'S FIELD SERVICES

- A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
- B. Provide service engineer to instruct Owner's representative in operation of systems plant and equipment for 3 day period.
- C. Provide basic operator training for 4 persons on data display, alarm and status descriptors, requesting data, execution of commands and request of logs. Include a minimum of 40 hours dedicated instructor time. Provide training on site.

3.04 DEMONSTRATION AND INSTRUCTIONS

- A. Demonstrate complete and operating system to Owner.

3.05 MAINTENANCE

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

- B. Provide service and maintenance of energy management and control systems for one years from Date of Substantial Completion.
- C. Provide four complete inspections, one in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.
- D. Provide complete service of systems, including call backs. Make minimum of 4 complete normal inspections of approximately 4 hours duration in addition to normal service calls to inspect, calibrate, and adjust controls, and submit written reports.

END OF SECTION 230923

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**SECTION 230934
VARIABLE-FREQUENCY MOTOR CONTROLLERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Variable-frequency motor controllers for low-voltage (600 V and less) AC motor applications.
- B. Overcurrent protective devices for motor controllers, including overload relays.

1.02 RELATED REQUIREMENTS

- A. Section 230529 - Hangers and Supports for HVAC Piping and Equipment.
- B. Section 230553 - Identification for HVAC Piping and Equipment: Identification products and requirements.
- C. Section 260526 - Grounding and Bonding for Electrical Systems.
- D. Section 260573 - Power System Studies: Additional criteria for selection and adjustment of equipment and associated protective devices specified in this section.

1.03 REFERENCE STANDARDS

- A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code); 1989 (Corrigendum 2019).
- B. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- C. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2008 (Reaffirmed 2020).
- D. NEMA IA 10039 - Control Circuit and Pilot Devices; 2025.
- E. NEMA IA 10030 - Industrial Control and Systems: Enclosures; 2024.
- F. NEMA IS 10033 - Industrial Control and Systems: Adjustable-Speed Drives; 2026.
- G. NEMA IS 10034 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems; 2022 (Reapproved 2025).
- H. NEMA IS 10035 - Application Guide for AC Adjustable Speed Drive Systems; 2021 (Reaffirmed 2025).
- I. NEMA ICS 61800-2 - Adjustable Speed Electrical Power Drive Systems, Part 2: General Requirements-Rating Specifications for Low Voltage Adjustable Frequency AC Power Drive Systems; 2023.
- J. NEMA MG 00001 - Motors and Generators; 2024.
- K. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.
- L. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- M. UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.
- N. UL 61800-5-1 - Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements – Electrical, Thermal, and Energy (Ed. 2); Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Coordinate work to provide motor controllers suitable for use with actual motors to be installed.
2. Coordinate work to provide controllers and associated wiring suitable for interface with control devices to be installed.
3. Coordinate arrangement with dimensions and clearance requirements of actual equipment to be installed.
4. Verify with manufacturer that conductor terminations are suitable for use with conductors to be installed.
5. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. Shop Drawings: Indicate dimensions, voltage, controller sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 1. Include wiring diagrams showing factory and field connections.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 1. Include contact information for entity providing contract maintenance and trouble call-back service.
- F. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- G. Maintenance Materials: Furnish following for Owner's use in maintenance of project.
 1. See Section 016000 - Product Requirements, for additional provisions.
 2. Air Filters: Two of each different type.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years documented experience.
 1. Authorized service facilities located within 200 miles of project site.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store in clean, dry space. Maintain factory wrapping or provide additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

1.08 FIELD CONDITIONS

- A. Maintain field conditions within required service conditions during and after installation.

1.09 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum 18 month manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. ABB.
- B. Square D.
- C. Substitutions: See Section 016000 - Product Requirements.
- D. Source Limitations: Furnish variable-frequency motor controllers and associated components produced by a single manufacturer and obtained from a single supplier.

2.02 VARIABLE-FREQUENCY MOTOR CONTROLLERS

- A. Provide variable-frequency motor control system consisting of required controller assemblies, operator interfaces, control power transformers, instrumentation and control wiring, sensors, accessories, system programming, etc. as necessary for complete operating system.
- B. Provide products listed, classified, and labeled as suitable for purpose intended.
- C. Variable-Frequency Motor Controller:
 - 1. Configuration: Packaged controller with across-the-line bypass.
 - 2. Power Conversion System: Diode-based, 6-pulse type.
 - 3. Control Method: Vector; closed-loop, with feedback.
 - 4. Filtering: Provide input/line reactor and output/load reactor.
- D. Controller Assemblies: Comply with NEMA IS 10033, NEMA IS 10034, and NEMA ICS 61800-2; list and label as complying with UL 61800-5-1 or UL 508A as applicable.
- E. Provide controllers selected for actual installed motors and coupled mechanical loads in accordance with NEMA IS 10035, NEMA MG 00001 Part 30, and recommendations of manufacturers of both controller and load, where not in conflict with specified requirements; considerations include, but are not limited to:
 - 1. Motor type (e.g., induction, reluctance, and permanent magnet); consider NEMA MG 00001 design letter or inverter duty rating for induction motors.
 - 2. Motor load type (e.g., constant torque, variable torque, and constant horsepower); consider duty cycle, impact loads, and high inertia loads.
 - 3. Motor nameplate data.
 - 4. Requirements for speed control range, speed regulation, and braking.
 - 5. Motor suitability for bypass starting method, where applicable.
- F. Devices on Load Side of Controller: Suitable for application across full controller output frequency range.
- G. Operating Requirements:
 - 1. Input Voltage Tolerance: Plus/minus 10 percent of nominal.
 - 2. Input Frequency Tolerance: Plus/minus 5 percent of nominal.
 - 3. Efficiency: Minimum of 96 percent at full speed and load.
 - 4. Input Displacement Power Factor: Minimum of 0.96 throughout speed and load range.
 - 5. Overload Rating:
 - a. Variable Torque Loads: Minimum of 110 percent of nominal for 60 seconds.

- b. Constant Torque Loads: Minimum of 150 percent of nominal for 60 seconds.
- H. Power Conversion System: Microprocessor-based, pulse width modulation type.
 - 1. Diode-based, 6-pulse type unless otherwise indicated.
- I. Control System:
 - 1. Provide microprocessor-based control system for automatic control, monitoring, and protection of motors. Include sensors, wiring, and connections necessary for functions and status/alarm indications specified.
 - 2. Provide integral operator interface for controller programming, display of status/alarm indications, fault reset, and local control functions including motor run/stop, motor forward/reverse selection, motor speed increase/decrease, and local/remote control selection.
 - 3. Control Functions:
 - a. Control Method: Selectable vector and scalar/volts per hertz unless otherwise indicated.
 - 1) Scalar/Volts per Hertz Control: Provide IR compensation for improved low-speed torque.
 - 2) Vector Control: Provide selectable autotuning function.
 - b. Adjustable acceleration and deceleration time; linear and S-curve ramps; selectable coast to stop.
 - c. Selectable braking control; DC injection or flux braking.
 - d. Adjustable minimum/maximum speed limits.
 - e. Adjustable pulse width modulation switching carrier frequency.
 - f. Adjustable motor slip compensation.
 - g. Selectable autorestart after noncritical fault; programmable number of time delay between restart attempts.
 - 4. Status Indications:
 - a. Motor run/stop status.
 - b. Motor forward/reverse status.
 - c. Local/remote control status.
 - d. Output voltage.
 - e. Output current.
 - f. Output frequency.
 - g. DC bus voltage.
 - h. Motor speed.
 - i. Elapsed run time.
 - j. Discrete input/output status.
 - k. Analog input/output values.
 - 5. Protective Functions/Alarm Indications:
 - a. Overcurrent.
 - b. Motor overload.
 - c. Undervoltage.
 - d. Overvoltage.
 - e. Controller overtemperature.
 - f. Input/output phase loss.
 - g. Output short circuit protection.
 - h. Output ground fault protection.
 - 6. Inputs:

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- a. Digital Input(s): Three.
 - b. Analog Input(s): Two.
 - 7. Outputs:
 - a. Analog Output(s): One.
 - b. Relay Output(s): Two.
 - 8. Communications: Compatible with connected systems. Provide accessories necessary for proper interface.
 - a. Serial Communications: RS-485; support for Modbus RTU protocol.
 - b. Ethernet Communications: Support for Modbus TCP protocol.
 - 9. Features:
 - a. Password-protected security access.
 - b. Event log.
 - J. Power Conditioning/Filtering:
 - 1. Provide DC link choke or input/line reactor for each controller unless otherwise indicated or required.
 - 2. Reactor Impedance: 3 percent, unless otherwise indicated or required.
 - K. Packaged Controllers: Controllers factory-mounted in separate enclosure with externally operable disconnect and specified accessories.
 - 1. Disconnects: Circuit breaker or disconnect switch type.
 - a. Disconnect Switches: Fusible type or nonfusible type with separate input fuses.
 - b. Provide externally operable handle with means for locking in OFF position. Provide safety interlock to prevent opening cover with disconnect in ON position with capability of overriding interlock for testing purposes.
 - c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
 - 2. Provide door-mounted remote operator interface.
 - 3. Packaged Controllers with Bypass: Provide contactors and controls to enable removal of variable-frequency controller from circuit.
 - a. Bypass Method: Manual, unless otherwise indicated.
 - b. Bypass Configuration: 3-contactor type, with contactors for bypass, drive output, and drive input.
 - c. Bypass Motor Starting Method: Full-voltage (across-the-line) with overload relay, unless otherwise indicated or required.
 - d. Overload Relays: Solid state or bimetallic thermal type.
 - 4. Pilot Devices Required:
 - a. Furnish local pilot devices for each unit as specified below unless otherwise indicated on drawings, except where equivalent function is provided by remote operator interface.
 - b. Packaged Controllers with Bypass:
 - 1) Bypass Mode Selector Switch: DRIVE/OFF/BYPASS.
 - 2) Motor Control Selector Switch: HAND/OFF/AUTO.
 - 3) Indicating Lights: For drive/bypass mode status, drive/bypass run status, and drive/bypass fault status.
 - L. Service Conditions:
 - 1. Provide controllers and associated components suitable for operation under following service conditions without derating:
 - a. Altitude: Less than 3,300 feet.
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- b. Ambient Temperature: Between 32 degrees F and 104 degrees F.
 - 2. Provide controllers and associated components suitable for operation at indicated ratings under service conditions at installed location.
 - M. Short Circuit Current Rating:
 - 1. Provide controllers with listed short circuit current rating not less than available fault current at installed location as determined by short circuit study performed in accordance with Section 260573.
 - 2. Provide line/input reactors where specified by manufacturer for required short circuit current rating.
 - N. Conductor Terminations: Suitable for use with conductors to be installed.
 - O. Enclosures:
 - 1. Comply with NEMA IA 10030.
 - 2. NEMA EN 10250 Environment Type or Equivalent IEC 60529 Rating: Unless otherwise indicated, as specified for following installation locations:
 - a. Outdoor Locations: Type 3R or Type 4.
 - 3. Finish: Manufacturer's standard unless otherwise indicated.
 - 4. Cooling: Forced air or natural convection as determined by manufacturer.
 - 5. Enclosure Space Heaters:
 - a. Provide in each controller enclosure installed outdoors and in unconditioned indoor spaces.
 - b. Size according to manufacturer's recommendations for worst case ambient temperature to prevent condensation.
 - c. Heater Control: Thermostat.
 - d. Heater Power Source: Provide connection to transformer factory-installed in enclosure or suitable external branch circuit as indicated or as required.

2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Overload Relays:
 - 1. Provide overload relays and, where applicable, associated current elements/heaters selected for actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.
 - 2. Comply with NEMA ICS 2.
 - 3. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
 - 4. Trip-free operation.
 - 5. Visible trip indication.
 - 6. Resettable:
 - a. Employ manual reset unless otherwise indicated.
 - b. Do not employ automatic reset with two-wire control.
 - 7. Bimetallic Thermal Overload Relays:
 - a. Interchangeable current elements/heaters.
 - b. Adjustable trip; plus/minus 10 percent of nominal, minimum.
 - c. Trip test function.
 - 8. Solid State Overload Relays:
 - a. Adjustable full load current.
 - b. Phase loss protection.
 - c. Phase imbalance protection.

- d. Ambient temperature insensitive.
- e. Thermal memory.
- f. Trip test function.
- g. Provide isolated alarm contact.

2.04 ACCESSORIES

- A. Auxiliary Contacts:
 - 1. Comply with NEMA IA 10039.
 - 2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each bypass motor starter, minimum.
- B. Pilot Devices:
 - 1. Comply with NEMA IA 10039; heavy-duty type.
 - 2. Pushbuttons: Unless otherwise indicated, provide momentary, nonilluminated type with flush button operator; normally open or normally closed as indicated or as required.
 - 3. Selector Switches: Unless otherwise indicated, provide maintained, nonilluminated type with knob operator; number of switch positions as indicated or as required.
 - 4. Indicating Lights: Push-to-test type unless otherwise indicated.
 - 5. Provide LED lamp source for indicating lights and illuminated devices.
- C. Control and Timing Relays:
 - 1. Comply with NEMA IA 10039.
 - 2. Provide number and type of relays indicated or required to perform necessary functions.
- D. Control Power Transformers:
 - 1. Size to accommodate burden of contactor coil(s) and connected auxiliary devices.
 - 2. Include primary and secondary fuses.

2.05 SOURCE QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Factory test controllers in accordance with NEMA ICS 61800-2.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that ratings of controllers are consistent with indicated requirements.
- C. Verify that mounting surfaces are ready to accept controllers.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install in accordance with NEMA IS 10034 and manufacturer's instructions.
- C. Do not exceed manufacturer's recommended maximum cable length between controller and motor.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 230529.

- F. Install controllers plumb and level.
- G. Provide grounding and bonding in accordance with Section 260526.
- H. Install field-installed devices, components, and accessories.
- I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- J. Set field-adjustable settings of controllers and associated components according to installed motor requirements, in accordance with recommendations of manufacturers of controller and load.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.17. Insulation-resistance test on control wiring listed as optional is not required.
- D. Packaged Controllers with Bypass: Test for proper operation in both drive and bypass modes.
- E. Test for proper interface with other systems.
- F. Correct deficiencies and replace damaged or defective controllers or associated components.

3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.05 CLEANING

- A. Clean dirt and debris from controller enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

3.06 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of controllers to Owner, and correct deficiencies or make adjustments as directed.
- D. Training: Train Owner's personnel on operation, adjustment, and maintenance of controllers and associated devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Location: At project site.

3.07 PROTECTION

- A. Protect installed controllers from subsequent construction operations.

3.08 MAINTENANCE

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

END OF SECTION 230934

SECTION 230993
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL**1.1 SECTION INCLUDES**

- A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.
- B. Sequence of operation for:
 - 1. Pumping Systems.
 - 2. Roof Top Units (RTU).
 - 3. Air Handling Units (AHU).
 - 4. Exhaust Fans (EF).
 - 5. Variable Air Volume Boxes (VAV).
 - 6. Unit Heaters (UH).

1.2 RELATED REQUIREMENTS

- A. Section 019113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- B. Section 230913 - Instrumentation and Control Devices for HVAC.
- C. Section 230923 - Direct-Digital Control System for HVAC.

1.3 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
 - 1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
 - 2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in Contract Documents.
 - 3. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
- C. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
 - 1. Label with settings, adjustable range of control and limits.
 - 2. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 HVAC CONTROL SEQUENCES

- A. All HVAC equipment shall operate in occupied/unoccupied modes as determined by the DDC building time clock system. Obtain the building occupancy schedule from the Owner.

3.2 GENERAL OCCUPIED/UNOCCUPIED OPERATION

- A. Scheduling:
 - 1. All HVAC equipment shall operate on an occupied/unoccupied schedule as provided by the Owner.
- B. Occupied/Unoccupied:
 - 1. Occupied:
 - a. Units will be energized and will provide the proper ventilation as required during occupancy of the spaces. Setpoints will be as described for the individual areas for normal human comfort.
 - 2. Unoccupied:
 - a. Equipment will be de-energized and outside air ventilation will be disabled. Temperature setpoints will be setback and equipment will maintain setback setpoints without ventilation.
- C. Warm-up Mode:
 - 1. The heating setpoint shall be incremented up from night heating setpoint to day heating setpoint.
 - 2. The increment value shall be determined by outside air temperature and a user adjustable optimal start period and the difference between the occupied and unoccupied setpoints.
 - 3. Once the heating setpoint exceeds the incremented setpoint warm-up shall commence.
 - 4. The heating source shall be modulated to maintain occupied heating setpoint.

3.3 PROJECT SPECIFIC EQUIPMENT

- A. CIRCLEVILLE ELEMENTARY BUILDING PUMPS
 - 1. Secondary Loop Pumps (CES-BP-1 & CES-BP-2)
 - a. All sets of primary pumps operate on a lead/lag automatic standby basis. This sequence represents each set of pumps (CES-BP-1 & CES-BP-2).
 - b. The lead pump is commanded on anytime the heating system is enabled or a software hand-off-automatic point is in the hand setting, otherwise the pumps are commanded off 5 minutes after the boilers are commanded off.
 - c. If the lead pump fails to prove run indication for more than 30 seconds the standby pump is started.
 - d. The speed of the operating pump shall be variable speed. Speed is to be determined by the differential pressure sensor located in the longest run of piping. Minimum speed to be determined by pump operating requirements. Minimum pressure to be based on pressure required to ensure flow to furthest piece of hydronic equipment.
 - e. The Lead Pump is changed automatically as per a user selectable run time equalization routine to equalize pump run times or as commanded by the system operator.
 - 2. Alarms:
 - a. Hot water pump failure

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- b. Hot water pumps differential pressure sensor low/high limits
 - c. System static pressure sensor low/high limit
 - B. ALL LEAD-LAG AUTOMATIC STANDBY PUMP SETS
 - 1. PAK-P-4 & 5, PAK-P-6 & 7, PAK-P-8 & 9
 - a. Pumps will operate on a lead/lag automatic standby basis.
 - 1) The lead pump is commanded on as described below or when a software hand-off-automatic point is in the hand setting.
 - 2) If the lead pump fails to prove run indication for more than 30 seconds the standby pump is started.
 - 3) The speed of the operating pump shall be constant speed.
 - 4) The Lead Pump is changed automatically as per a user selectable run time equalization routine to equalize pump run times or as commanded by the system operator.
 - b. Alarms:
 - 1) Pump failure
 - C. RADIANT PANEL STEP-DOWN LOOPS
 - 1. CAFETERIA: CVMS-CP-1
 - a. Occupied Mode
 - 1) The existing duct-mounted hot water coil shall be the primary source of heating in during occupied mode. If the outside air temperature falls below 60°F (adjustable), and the space temperature falls below the setpoint, the circulator pump shall be commanded on. The loop three-way valve shall modulate to maintain a return water temperature of 120°F (adjustable).
 - 2) When the space temperature is satisfied, the circulator pump shall be commanded off. The loop three-way valve shall close and the water shall bypass the radiant panel loop. The associated duct-mounted hot water coil two-way valve shall continue to modulate to maintain space temperature setpoint.
 - b. Unoccupied Mode
 - 1) The radiant panels shall be the primary source of heating in each zone during unoccupied mode. If the space temperature setpoint falls below 60°F (adjustable), the circulator pump shall be commanded on. The radiant panel zone two-way valve shall open. The loop three-way valve shall modulate to maintain a return water temperature of 120°F (adjustable).
 - 2) When the space temperature is satisfied, the circulator pump shall be commanded off and the three-way valve shall close.
 - c. Alarms:
 - 1) Pump failure
 - 2. MAIN OFFICES: CVMS-CP-2
 - a. Occupied Mode
 - 1) The VAV hot water coil shall be the primary source of heating in each zone during occupied mode. If the outside air temperature falls below 60°F (adjustable), the circulator pump shall be commanded on. If the space temperature falls below the setpoint, the radiant panel zone two-way valve shall
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- open. The loop three-way valve shall modulate to maintain a return water temperature of 120°F (adjustable).
- 2) When all space temperatures are satisfied, the radiant panel zone two-way valve shall close and the radiant panels shall be bypassed. The loop three-way valve shall close and the water shall bypass the radiant panel loop. The associated VAV hot water coil two-way valve shall continue to modulate to maintain space temperature setpoint.
- b. Unoccupied Mode
 - 1) The radiant panels shall be the primary source of heating in each zone during unoccupied mode. If the space temperature setpoint falls below 60°F (adjustable), the circulator pump shall be commanded on. The radiant panel zone two-way valve shall open. The loop three-way valve shall modulate to maintain a return water temperature of 120°F (adjustable).
 - 2) When all space temperatures are satisfied, the radiant panel zone two-way valve shall close and the radiant panels will be bypassed. The loop three-way valve shall close and the water shall bypass the radiant panel loop.
 - c. Alarms:
 - 1) Pump failure
- D. CVMS-RTU-10
1. System Description
 - a. CVMS-RTU-10 consists of a variable volume supply fan, variable volume return/exhaust fan, outside air dampers, return air dampers, exhaust air dampers, energy recovery wheels, direct expansion (DX) heating/cooling coils (compressor heat pump system), and hot gas reheat.
 - b. Each zone has a variable air volume (VAV) box with a hot water reheat coil, which serve various spaces. Various spaces have hot water baseboard radiation or hot water radiant ceiling panels with two-position zone control valves and space temperature sensors. The VAV boxes minimum position shall provide the minimum air volume as required by code during heating and cooling modes and shall open further to provide additional air volume during cooling mode. Space relief is accomplished through the constant volume return/exhaust fan.
 - c. Components shall adhere to the following sequence.
 2. Automatic/Manual Control
 - a. The units disconnect is accompanied by a H-O-A (hand/off/auto) switch on the starter panel. In the "H" position, the system shall be energized, and the system safety devices shall protect the circuit. With the H-O-A switch on the starter panel in the "H" position, the unit shall start. With the H-O-A switch in the "A" position, the unit shall operate in response to EMCS control and system safety circuits.
 3. Optimum Start
 - a. The rooftop units scheduled start time, controlled by the EMCS system, shall be altered by mathematical start program calculation. The result of the calculation shall be to compute the equipment start time so that the space temperature can be moved from its unoccupied mode setting, to the occupied mode setting for the space controlled, early enough to meet the scheduled start time for the space.
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4. Occupied Mode

- a. The EMCS will start the unit supply fan based on a time-of-day schedule. The supply fan will be energized continuously whenever the zone is scheduled to be occupied and the outside air damper shall open to minimum position. The supply fan, via the fan VFD controller, shall vary speed to maintain a static pressure setpoint in the main supply duct. The static pressure setpoint shall be set at 1.25" W.C. (adjustable). The unit relief/exhaust fan, via the fan VFD controller, shall ramp up to match the position of the outside air damper to equalize the volume of relief air with the volume of outside air. The EMCS will monitor space temperature. The unit heating DX heating shall provide primary heat and the hot water heating valves of the reheat coils and radiant panels shall modulate open as secondary heat as described below to maintain setpoint.
- b. When the outside air temperature is below 60 °F, the outside air dampers will modulate close to minimum position and the DX heating coil will cycle to maintain the space temperature setpoint of 68 °F. If the space temperature falls below the heating setpoint, the variable air volume hot water coil control valve shall modulate open to maintain space temperature. If the system is equipped with auxiliary space heating components and the space temperature falls 2 °F below the setpoint, the auxiliary space heating components shall be indexed on to maintain setpoint.
- c. If the space temperature rises above the cooling setpoint of 75 °F (adjustable), and the EMCS indicates that economizer operation is appropriate, the outside air damper will modulate further open to maintain setpoint, the heating components shall be disabled. The outside air damper will be restricted to limit the minimum discharge air temperature to a setpoint of 55 °F (adjustable) while the space temperature is above the cooling setpoint.
- d. If the space temperature rises above the cooling setpoint of 75 °F (adjustable), and the EMCS indicates that economizer operation is not appropriate, the outside air dampers will modulate close to minimum position and the DX cooling stages will be energized.
- e. Cooling with assisted Economizer:
 - 1) Economizer operation shall use an algorithm comparing indoor air and outdoor air enthalpy to determine if cooling or assisted cooling is viable. DX cooling and economizer cooling will be allowed to operate simultaneously if the algorithm confirms assisted cooling is viable.
- f. The EMCS will monitor the return air relative humidity (%RH) and if the return air %RH rises above the setpoint of 60% (adjustable), the EMCS will enable DX cooling stages. The EMCS will monitor the discharge air temperature and the space temperature. If the discharge air temperature falls below 55 °F. (adjustable) or the space temperature falls below the cooling setpoint, the EMCS will enable the hot gas bypass coil valve.

5. Energy Recovery Wheel Control

- a. This subsection is to be followed for units designated to have energy recovery. If the unit is not fitted with energy recovery, this subsection shall be disregarded.
 - 1) The energy recovery wheel motor will be enabled whenever the supply and return/exhaust fans are enabled except as noted here:
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- (a) The energy recovery wheel motor shall be disabled when the DDC SYSTEM determines that it is beneficial to use additional outside air for cooling (economizer mode).
 - (b) The energy recovery wheel motor shall be disabled for two minutes out of each 30-minute period when the outdoor air temperature is at or below zero degrees F (defrost cycle).
- 6. Unoccupied Mode
 - a. The "time of day" program shall cause the rooftop unit to go to unoccupied mode settings when called for by the schedule program. The space temperature heating setpoint shall be set to 60 degrees F (adj.) winter. In the unoccupied mode, the outside air damper and exhaust air damper shall be closed. The EMCS system shall use the space temperature sensor to cycle the rooftop unit and dual temperature control valve (in heating mode) to prevent the space temperature from falling below the minimum setpoint. The outside air damper and exhaust air damper shall remain closed. Cooling is not available during unoccupied periods.
 - b. When the occupied override button is depressed on the space sensor, the unit shall go into occupied mode for a predetermined amount of time of 2 hours (adj.).
- 7. Alarms
 - a. Fan Failure
 - 1) If status of a fan, which has been called by the EMCS system to start, has not been verified as running within a period of 10 seconds (adj.), an alarm shall be sent to the operator's workstation. The fan shall be identified by a description of what it serves, (i.e., AHU-1 supply fan) and shall be tagged as a "fan failure".
 - b. Low Limit Thermostat
 - 1) If the air leaving the hot water coil drops below 38 degrees f (adj.) the supply fan shall be stopped via hard wire interlock and the EMCS system shall be alerted by a set of dry contacts provided by the low limit thermostat. An alarm shall be sent to the operator's workstation. The unit shall be identified by its call number (i.e. AHU-1) and shall be tagged as a "low limit thermostat alarm". The unit must be manually reset before it can be restarted.
 - c. Refrigerant Leak Detection
 - 1) If the factory installed refrigerant leak detection sensor and control board detects refrigerant concentration above 25% of the ASHRAE Std. 34 listed Lower Flammability Limit (LFL), the outdoor unit compressors shall be commanded off and the unit supply fans shall be commanded on at 100% capacity. Once the refrigerant concentration falls below 25% of the LFL, maintain fan speeds for 5 additional minutes. Unit will remain in a hard lockout until manually reset.
- 8. Monitor and Trend:
 - a. Outdoor Air Ventilation Flow.
 - b. Outdoor Air Temperature.
 - c. Outdoor Air Humidity.
 - d. Supply Air Flow Rate.
 - e. Supply Air Temperature.
 - f. Supply Air Humidity.

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- g. Supply Fan Speed.
 - h. Return Air Flow Temperature.
 - i. Space Pressurization relative to outdoors.
 - E. CVMS-RTU-11
 - 1. System Description
 - a. CVMS-RTU-10 consists of a variable volume supply fan, variable volume return/exhaust fan, outside air dampers, return air dampers, exhaust air dampers, energy recovery wheels, direct expansion (DX) heating/cooling coils (compressor heat pump system), and hot gas reheat.
 - b. Each zone has a variable air volume (VAV) box with a hot water reheat coil, which serve various spaces. Various spaces have hot water baseboard radiation or hot water radiant ceiling panels with two-position zone control valves and space temperature sensors. The VAV boxes minimum position shall provide the minimum air volume as required by code during heating and cooling modes and shall open further to provide additional air volume during cooling mode. Space relief is accomplished through the constant volume return/exhaust fan.
 - c. Components shall adhere to the following sequence.
 - 2. Automatic/Manual Control
 - a. The units disconnect is accompanied by a H-O-A (hand/off/auto) switch on the starter panel. In the "H" position, the system shall be energized, and the system safety devices shall protect the circuit. With the H-O-A switch on the starter panel in the "H" position, the unit shall start. With the H-O-A switch in the "A" position, the unit shall operate in response to EMCS control and system safety circuits.
 - 3. Optimum Start
 - a. The rooftop units scheduled start time, controlled by the EMCS system, shall be altered by mathematical start program calculation. The result of the calculation shall be to compute the equipment start time so that the space temperature can be moved from its unoccupied mode setting, to the occupied mode setting for the space controlled, early enough to meet the scheduled start time for the space.
 - 4. Occupied Mode
 - a. The EMCS will start the unit supply fan based on a time-of-day schedule. The supply fan will be energized continuously whenever the zone is scheduled to be occupied and the outside air damper shall open to minimum position. The supply fan, via the fan VFD controller, shall vary speed to maintain a static pressure setpoint in the main supply duct. The static pressure setpoint shall be set at 1.25" W.C. (adjustable). The unit relief/exhaust fan, via the fan VFD controller, shall ramp up to match the position of the outside air damper to equalize the volume of relief air with the volume of outside air. The EMCS will monitor space temperature. The unit heating DX heating shall provide primary heat and the hot water heating valves of the reheat coils and radiant panels shall modulate open as secondary heat as described below to maintain setpoint.
 - b. When the outside air temperature is below 60 °F, the outside air dampers will modulate close to minimum position and the DX heating coil will cycle to maintain the space temperature setpoint of 68 °F. If the space temperature falls below the
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- heating setpoint, the variable air volume hot water coil control valve shall modulate open to maintain space temperature. If the system is equipped with auxiliary space heating components and the space temperature falls 2 °F below the setpoint, the auxiliary space heating components shall be indexed on to maintain setpoint.
- c. If the space temperature rises above the cooling setpoint of 75 °F (adjustable), and the EMCS indicates that economizer operation is appropriate, the outside air damper will modulate further open to maintain setpoint, the heating components shall be disabled. The outside air damper will be restricted to limit the minimum discharge air temperature to a setpoint of 55 °F (adjustable) while the space temperature is above the cooling setpoint.
 - d. If the space temperature rises above the cooling setpoint of 75 °F (adjustable), and the EMCS indicates that economizer operation is not appropriate, the outside air dampers will modulate close to minimum position and the DX cooling stages will be energized.
 - e. Cooling with assisted Economizer:
 - 1) Economizer operation shall use an algorithm comparing indoor air and outdoor air enthalpy to determine if cooling or assisted cooling is viable. DX cooling and economizer cooling will be allowed to operate simultaneously if the algorithm confirms assisted cooling is viable.
 - f. The EMCS will monitor the return air relative humidity (%RH) and if the return air %RH rises above the setpoint of 60% (adjustable), the EMCS will enable the DX cooling stages. The EMCS will monitor the discharge air temperature and the space temperature. If the discharge air temperature falls below 55 °F. (adjustable) or the space temperature falls below the cooling setpoint, the EMCS will enable the hot gas bypass coil valve.
5. Energy Recovery Wheel Control
- a. This subsection is to be followed for units designated to have energy recovery. If the unit is not fitted with energy recovery, this subsection shall be disregarded.
 - 1) The energy recovery wheel motor will be enabled whenever the supply and return/exhaust fans are enabled except as noted here:
 - (a) The energy recovery wheel motor shall be disabled when the DDC SYSTEM determines that it is beneficial to use additional outside air for cooling (economizer mode).
 - (b) The energy recovery wheel motor shall be disabled for two minutes out of each 30-minute period when the outdoor air temperature is at or below zero degrees F (defrost cycle).
6. Unoccupied Mode
- a. The “time of day” program shall cause the rooftop unit to go to unoccupied mode settings when called for by the schedule program. The space temperature heating setpoint shall be set to 60 degrees F (adj.) winter. In the unoccupied mode, the outside air damper and exhaust air damper shall be closed. The EMCS system shall use the space temperature sensor to cycle the rooftop unit and dual temperature control valve (in heating mode) to prevent the space temperature from falling below the minimum setpoint. The outside air damper and exhaust air damper shall remain closed. Cooling is not available during unoccupied periods.

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- b. When the occupied override button is depressed on the space sensor, the unit shall go into occupied mode for a predetermined amount of time of 2 hours (adj.).
 - 7. Alarms
 - a. Fan Failure
 - 1) If status of a fan, which has been called by the EMCS system to start, has not been verified as running within a period of 10 seconds (adj.), an alarm shall be sent to the operator's workstation. The fan shall be identified by a description of what it serves, (i.e., AHU-1 supply fan) and shall be tagged as a "fan failure".
 - b. Low Limit Thermostat
 - 1) If the air leaving the hot water coil drops below 38 degrees f (adj.) the supply fan shall be stopped via hard wire interlock and the EMCS system shall be alerted by a set of dry contacts provided by the low limit thermostat. An alarm shall be sent to the operator's workstation. The unit shall be identified by its call number (i.e. AHU-1) and shall be tagged as a "low limit thermostat alarm". The unit must be manually reset before it can be restarted.
 - c. Refrigerant Leak Detection
 - 1) If the factory installed refrigerant leak detection sensor and control board detects refrigerant concentration above 25% of the ASHRAE Std. 34 listed Lower Flammability Limit (LFL), the outdoor unit compressors shall be commanded off and the unit supply fans shall be commanded on at 100% capacity. Once the refrigerant concentration falls below 25% of the LFL, maintain fan speeds for 5 additional minutes. Unit will remain in a hard lockout until manually reset.
 - 8. Monitor and Trend:
 - a. Outdoor Air Ventilation Flow.
 - b. Outdoor Air Temperature.
 - c. Outdoor Air Humidity.
 - d. Supply Air Flow Rate.
 - e. Supply Air Temperature.
 - f. Supply Air Humidity.
 - g. Supply Fan Speed.
 - h. Return Air Flow Temperature.
 - i. Space Pressurization relative to outdoors.
 - F. PAK-AHU-1
 - 1. System Description:
 - a. PAK-AHU-1 consists of a supply fan, exhaust fan, energy recovery wheel, outside air dampers, exhaust air dampers, hot gas reheat, a hot water heating coil, a DX cooling coil, and a reject heat dehumidification coil. A remote condenser is also integrated into this system. Space relief is accomplished through the exhaust plenum in the mechanical room.
 - 2. Pre Occupancy Purge
 - a. The air handling unit shall perform a preoccupancy purge 30 minutes prior to occupancy. The cycle shall consist of a 30-minute fan operation (both supply and return/exhaust air fans shall operate) with the outside air damper open to maximum occupant load position (3360 cfm), the return air damper shall modulate inversely in
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response to the outdoor air damper position. The exhaust air damper shall modulate in conjunction with the outside air damper. The heating and cooling equipment shall index according to their unoccupied sequences (see below) in order that at minimum, the purge shall meet the unoccupied temperature setpoint at completion of the purge.

3. Optimum Start

- a. The air handling units scheduled start time, controlled by the DDC system, shall be altered by mathematical start program calculation. The result of the calculation shall be to compute the equipment start time so that the space temperature can be moved from its unoccupied mode setting, to the occupied mode setting for the space controlled, early enough to meet the scheduled start time for the space.

4. Occupied mode:

- a. The "time of day" program for occupied times shall cause the constant volume supply and return/exhaust fans to start and run continuously and controls to be energized. The air handling unit control shall be energized and switched from unoccupied temperature setting to the occupied setting. The BMS will monitor space temperature. The hot water heating coil control valve and the DX cooling coil compressors shall modulate/cycle as described below to maintain setpoint.
- b. Space Temperature Control – Winter
 - 1) First Heating Stage:
 - (a) On a call for heating, energy is recovered from the exhaust air by passing it through the circuit "A" evaporator.
 - (b) The cooled exhaust air is then expelled from the unit.
 - (c) The recovered energy from the exhaust air stream and the refrigerant heat of rejection are sent to the circuit "A" reheat coil where outside air is heated.
 - 2) Second Heating Stage:
 - (a) If additional heat is required to maintain the space set point, the heating system shall be energized.
 - (b) A 0 to 10 VDC signal will be provided to a field supplied and field installed modulating heating hot water control valve.
- c. Space Temperature Control – Summer
 - 1) First Cooling Stage:
 - (a) The exhaust damper located before the evaporator coils opens and exhausts room air before the evaporator coils.
 - (b) Circuit "A" compressor(s) will start and operate.
 - (c) The reheat coil will be inactive during cooling operation.
 - (d) The heat of rejection shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator.
 - 2) Second Cooling Stage:
 - (a) Circuit "B" compressor(s) will start and operate.
 - (b) The reheat coil will be inactive during cooling operation.
 - (c) The heat of rejection shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator.
 - 3) Economizer operation will be disabled when the outside air temperature is above 60 degrees F (adjustable).

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- 4) The EMCS will allow occupants to manually adjust the space temperature setpoint up or down 2 degrees F (adj.), by moving a setpoint adjustment lever located at the space temperature sensor. Occupants will also have the ability to return the zone to the occupied mode for 2 hours (adj.) by depressing a pushbutton override, also located at the sensor.
 5. Dehumidification Mode:
 - a. First Stage
 - 1) Circuit "B" compressor(s) will start and operate.
 - 2) The exhaust damper located before the evaporator coils opens and exhausts room air before the evaporator coils.
 - 3) The reheat coil will be active.
 - 4) Any remaining heat of rejection not used by the reheat coil shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator.
 - b. Second Stage:
 - 1) Circuit "A" compressor(s) will start and operate.
 - 2) The reheat coil will be active.
 - 3) Any remaining heat of rejection not used by the reheat coil shall be directed to the heat sink or sinks in the priority they are assigned as defined in the controller by the building operator.
 6. Suggested Heat of Rejection Priorities:
 - a. The heat of rejection priority #1 shall be directed to the pool water condenser.
 - b. If the pool water temperature is at setpoint, the heat of rejection shall be directed to the condenser reheat coil if the supply air temperature is below setpoint. This shall be considered priority #2.
 - c. If the pool water temperature and supply air temperature are both at setpoint, the heat of rejection shall be directed to the remote condenser. This shall be considered priority #3.
 7. Purge Mode
 - a. Purge mode shall be a manual process to be initiated by the building operator.
 - b. Purge mode is used to clear airborne byproducts of the pool disinfection process as required by the operator. This is typically done when the space is not occupied. When the need is determined, a signal is given via a contact closure or through the Building Management System (BMS) network. The unit will bring in the specified amount of outdoor air (typically at a very high flow rate).
 - c. During purge mode the refrigeration system is disabled. The heating system is controlled from the supply air temperature sensor only and is set to a point that only avoids major condensation from occurring at the ducts and diffusers.
 8. Unoccupied Mode
 - a. When the zone is scheduled to be unoccupied, the fan will be de-energized, the outside air damper will be closed and the space temperature setpoint reduced to 55 degrees F (adjustable). If the space temperature falls 1 degree F below this setpoint, the unit fan will start, the outside air damper will remain closed, and the heating operation will be enabled. The unit fan will remain on until the room temperature
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increases 2 degrees F above setpoint. When this occurs, the fan will be de-energized, and the heating mode will be disabled.

9. Monitor:

- a. Outdoor air flow rate.
- b. Outdoor air temperature.
- c. Outdoor air humidity.
- d. Supply air flow rate.
- e. Supply air temperature.
- f. Supply air humidity.
- g. Supply fan speed.
- h. Return air flow rate.
- i. Return air temperature.
- j. Return fan speed.
- k. Pre-filter differential pressure.
- l. Final filter differential pressure.

10. Alarms:

- a. Drain pan overflow - If the drain pan level sensor is activated, the BMS shall alarm.
- b. Fan failure - If a fan (supply or return) is enabled and the fan status is off for more than 30 seconds (adj.), the BMS shall alarm.
- c. Loaded return filter alarm.
- d. Loaded supply filter alarm.
- e. High discharge air temperature - If the discharge air temperature exceeds 120 deg F (adj.), the BMS shall alarm.
- f. Discharge air temperature low limit - If the discharge air temperature is less than 40 deg F (adj.), the BMS shall alarm.
- g. Freezestat.
- h. High discharge static pressure.
- i. Coil pump failure - If the hot water coil pump is enabled and the pump status is off for more than 30 seconds (adj.), the BMS shall alarm.
- j. Energy recovery wheel motor failure - If the energy recovery wheel motor is enabled and the pump status is off for more than 30 seconds (adj.), the BMS shall alarm.
- k. Refrigerant Leak Detection
 - 1) If the factory installed refrigerant leak detection sensor and control board detects refrigerant concentration above 25% of the ASHRAE Std. 34 listed Lower Flammability Limit (LFL), the outdoor unit compressors shall be commanded off and the unit supply fans shall be commanded on at 100% capacity. Once the refrigerant concentration falls below 25% of the LFL, maintain fan speeds for 5 additional minutes. Unit will remain in a hard lockout until manually reset.

G. PAK-AHU-2

1. System Description:

- a. PAK-AHU-2 consists of a supply fan, exhaust fan, energy recovery wheel, outside air dampers, exhaust air dampers, hot gas reheat, a hot water heating coil, and a DX

cooling coil. Space relief is accomplished through the exhaust plenum in the mechanical room.

2. Automatic/Manual Control
 - a. The units disconnect is accompanied by a H-O-A (hand/off/auto) switch on the starter panel. With the H-O-A switch on the starter panel in the "H" position, the unit shall start. With the H-O-A switch in the "A" position, the unit shall operate in response to EMCS control and system safety circuits.
3. Optimum Start
 - a. The air handling units scheduled start time, controlled by the DDC system, shall be altered by mathematical start program calculation. The result of the calculation shall be to compute the equipment start time so that the space temperature can be moved from its unoccupied mode setting, to the occupied mode setting for the space controlled, early enough to meet the scheduled start time for the space.
4. Occupied mode:
 - a. The EMCS will start the unit supply and relief/exhaust fans based on a time-of-day schedule. The fans will be energized continuously whenever the zone is scheduled to be occupied. The outside air dampers shall open fully to provide the minimum required outside air to meet the volumetric flow rates indicated on the ventilation schedule. The relief air ventilator damper shall index open to match the position of the outside air damper to equalize the volume of relief air with the volume of outside air. The EMCS will monitor space temperature in each individual space. The DX cooling/heating coil compressors shall modulate/cycle as described below to maintain setpoint.
 - b. When the outside air temperature is below 60 °F, the outside air dampers will modulate close to minimum position and the DX heating coil will cycle to maintain the space temperature setpoint of 68 °F. If the space temperature falls below the heating setpoint, the auxiliary hot water coil control valve shall modulate open to maintain space temperature. If the system is equipped with auxiliary space heating components and the space temperature falls 2°F below the setpoint, the auxiliary space heating components shall be indexed on to maintain setpoint.
 - c. If the space temperature rises above the cooling setpoint of 75 °F (adjustable), and the EMCS indicates that economizer operation is appropriate, the outside air damper will modulate further open to maintain setpoint, the heating components shall be disabled. The outside air damper will be restricted to limit the minimum discharge air temperature to a setpoint of 55 degrees F (adjustable) while the space temperature is above the cooling setpoint.
 - d. If the space temperature rises above the cooling setpoint of 75 degrees F (adjustable), and the EMCS indicates that economizer operation is not appropriate, the outside air dampers will modulate close to minimum position and the DX cooling stages will be energized.
 - e. Economizer operation shall use an algorithm comparing indoor air and outdoor air enthalpy to determine if cooling or assisted cooling is viable. DX cooling and economizer cooling will be allowed to operate simultaneously if the algorithm confirms assisted cooling is viable.

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- f. The EMCS will monitor the return air relative humidity (%RH) and if the return air %RH rises above the setpoint of 60% (adjustable), the EMCS will enable DX cooling stages. The EMCS will monitor the discharge air temperature and the space temperature. If the discharge air temperature falls below 55 degrees F. (adjustable) or the space temperature falls below the cooling setpoint, the EMCS will enable the hot gas bypass coil valve.
 - 5. Unoccupied Mode
 - a. When the zone is scheduled to be unoccupied, the fan will be de-energized, the outside air damper will be closed and the space temperature setpoint reduced to 60 degrees F (adjustable). If the space temperature falls 1 degree F below this setpoint and the system contains auxiliary space heating components, the auxiliary space heating components shall be indexed on to maintain setpoint. If the system does not contain auxiliary space heating components, the unit fan will start, the outside air damper will remain closed, and the heating operation will be enabled. The unit fan will remain on until the room temperature increases 2 degrees F above setpoint. When this occurs, the fan will be de-energized, and the heating mode will be disabled.
 - 6. Energy Recovery Wheel Control
 - a. The energy recovery wheel motor will be enabled whenever the supply and return/exhaust fans are enabled except as noted here:
 - 1) The energy recovery wheel motor shall be disabled when the BMS determines that it is beneficial to use additional outside air for cooling (economizer mode).
 - 2) The energy recovery wheel motor shall be disabled for two minutes out of each 30 minute period when the outdoor air temperature is at or below zero degrees F (defrost cycle).
 - 7. Alarm:
 - a. Drain pan overflow - If the drain pan level sensor is activated, the BMS shall alarm.
 - b. Fan failure - If a fan (supply or return) is enabled and the fan status is off for more than 30 seconds (adj.), the BMS shall alarm.
 - c. Loaded return filter alarm.
 - d. Loaded supply filter alarm.
 - e. High discharge air temperature - If the discharge air temperature exceeds 120 deg F (adj.), the BMS shall alarm.
 - f. Discharge air temperature low limit - If the discharge air temperature is less than 40 deg F (adj.), the BMS shall alarm.
 - g. Freezestat.
 - h. High discharge static pressure.
 - i. Coil pump failure - If the hot water coil pump is enabled and the pump status is off for more than 30 seconds (adj.), the BMS shall alarm.
 - j. Energy recovery wheel motor failure - If the energy recovery wheel motor is enabled and the pump status is off for more than 30 seconds (adj.), the BMS shall alarm.
 - k. Refrigerant Leak Detection
 - 1) If the factory installed refrigerant leak detection sensor and control board detects refrigerant concentration above 25% of the ASHRAE Std. 34 listed Lower Flammability Limit (LFL), the outdoor unit compressors shall be commanded off
-

and the unit supply fans shall be commanded on at 100% capacity. Once the refrigerant concentration falls below 25% of the LFL, maintain fan speeds for 5 additional minutes. Unit will remain in a hard lockout until manually reset.

8. Monitor and Trend:
 - a. Outdoor Air Ventilation Flow.
 - b. Outdoor Air Temperature.
 - c. Outdoor Air Relative Humidity.
 - d. Supply Air Flow Rate.
 - e. Supply Air Temperature.
 - f. Supply Air Relative Humidity.
 - g. Supply Fan Speed.
 - h. Return Air Temperature.
 - i. Space Pressurization relative to outdoors.
- H. PAK-AHU-3
 1. System Description:
 - a. PAK-AHU-3 consists of a supply fan, exhaust fan, energy recovery wheel, outside air dampers, exhaust air dampers, hot gas reheat, a hot water heating coil, and a DX cooling coil. Space relief is accomplished through the exhaust plenum in the mechanical room.
 2. Automatic/Manual Control
 - a. The units disconnect is accompanied by a H-O-A (hand/off/auto) switch on the starter panel. With the H-O-A switch on the starter panel in the "H" position, the unit shall start. With the H-O-A switch in the "A" position, the unit shall operate in response to EMCS control and system safety circuits.
 3. Optimum Start
 - a. The air handling units scheduled start time, controlled by the DDC system, shall be altered by mathematical start program calculation. The result of the calculation shall be to compute the equipment start time so that the space temperature can be moved from its unoccupied mode setting, to the occupied mode setting for the space controlled, early enough to meet the scheduled start time for the space.
 4. Occupied mode:
 - a. The EMCS will start the unit supply and relief/exhaust fans based on a time-of-day schedule. The fans will be energized continuously whenever the zone is scheduled to be occupied. The outside air dampers shall open fully to provide the minimum required outside air to meet the volumetric flow rates indicated on the ventilation schedule. The relief air ventilator damper shall index open to match the position of the outside air damper to equalize the volume of relief air with the volume of outside air. The EMCS will monitor space temperature in each individual space. The DX cooling/heating coil compressors shall modulate/cycle as described below to maintain setpoint.
 - b. When the outside air temperature is below 60 °F, the outside air dampers will modulate close to minimum position and the DX heating coil will cycle to maintain the space temperature setpoint of 68 °F. If the space temperature falls below the heating setpoint, the auxiliary hot water coil control valve shall modulate open to

maintain space temperature. If the system is equipped with auxiliary space heating components and the space temperature falls 2°F below the setpoint, the auxiliary space heating components shall be indexed on to maintain setpoint.

- c. If the space temperature rises above the cooling setpoint of 75 °F (adjustable), and the EMCS indicates that economizer operation is appropriate, the outside air damper will modulate further open to maintain setpoint, the heating components shall be disabled. The outside air damper will be restricted to limit the minimum discharge air temperature to a setpoint of 55 degrees F (adjustable) while the space temperature is above the cooling setpoint.
 - d. If the space temperature rises above the cooling setpoint of 75 degrees F (adjustable), and the EMCS indicates that economizer operation is not appropriate, the outside air dampers will modulate close to minimum position and the DX cooling stages will be energized.
 - e. Economizer operation shall use an algorithm comparing indoor air and outdoor air enthalpy to determine if cooling or assisted cooling is viable. DX cooling and economizer cooling will be allowed to operate simultaneously if the algorithm confirms assisted cooling is viable.
 - f. The EMCS will monitor the return air relative humidity (%RH) and if the return air %RH rises above the setpoint of 60% (adjustable), the EMCS will enable DX cooling stages. The EMCS will monitor the discharge air temperature and the space temperature. If the discharge air temperature falls below 55 degrees F. (adjustable) or the space temperature falls below the cooling setpoint, the EMCS will enable the hot gas bypass coil valve.
5. Unoccupied Mode
- a. When the zone is scheduled to be unoccupied, the fan will be de-energized, the outside air damper will be closed and the space temperature setpoint reduced to 60 degrees F (adjustable). If the space temperature falls 1 degree F below this setpoint and the system contains auxiliary space heating components, the auxiliary space heating components shall be indexed on to maintain setpoint. If the system does not contain auxiliary space heating components, the unit fan will start, the outside air damper will remain closed, and the heating operation will be enabled. The unit fan will remain on until the room temperature increases 2 degrees F above setpoint. When this occurs, the fan will be de-energized, and the heating mode will be disabled.
6. Energy Recovery Wheel Control
- a. The energy recovery wheel motor will be enabled whenever the supply and return/exhaust fans are enabled except as noted here:
 - 1) The energy recovery wheel motor shall be disabled when the BMS determines that it is beneficial to use additional outside air for cooling (economizer mode).
 - 2) The energy recovery wheel motor shall be disabled for two minutes out of each 30 minute period when the outdoor air temperature is at or below zero degrees F (defrost cycle).
7. Alarm:
- a. Drain pan overflow - If the drain pan level sensor is activated, the BMS shall alarm.

- b. Fan failure - If a fan (supply or return) is enabled and the fan status is off for more than 30 seconds (adj.), the BMS shall alarm.
 - c. Loaded return filter alarm.
 - d. Loaded supply filter alarm.
 - e. High discharge air temperature - If the discharge air temperature exceeds 120 deg F (adj.), the BMS shall alarm.
 - f. Discharge air temperature low limit - If the discharge air temperature is less than 40 deg F (adj.), the BMS shall alarm.
 - g. Freezestat.
 - h. High discharge static pressure.
 - i. Coil pump failure - If the hot water coil pump is enabled and the pump status is off for more than 30 seconds (adj.), the BMS shall alarm.
 - j. Energy recovery wheel motor failure - If the energy recovery wheel motor is enabled and the pump status is off for more than 30 seconds (adj.), the BMS shall alarm.
 - k. Refrigerant Leak Detection
 - 1) If the factory installed refrigerant leak detection sensor and control board detects refrigerant concentration above 25% of the ASHRAE Std. 34 listed Lower Flammability Limit (LFL), the outdoor unit compressors shall be commanded off and the unit supply fans shall be commanded on at 100% capacity. Once the refrigerant concentration falls below 25% of the LFL, maintain fan speeds for 5 additional minutes. Unit will remain in a hard lockout until manually reset.
8. Monitor and Trend:
- a. Outdoor Air Ventilation Flow.
 - b. Outdoor Air Temperature.
 - c. Outdoor Air Relative Humidity.
 - d. Supply Air Flow Rate.
 - e. Supply Air Temperature.
 - f. Supply Air Relative Humidity.
 - g. Supply Fan Speed.
 - h. Return Air Temperature.
 - i. Space Pressurization relative to outdoors.
- I. ROOF MOUNTED EXHAUST FANS
- 1. Unoccupied Mode: Fan shall be disabled in unoccupied mode.
 - 2. Occupied Mode: Fan shall be enabled in occupied mode.
 - 3. Backdraft damper - Open/Closed:
 - a. The exhaust air damper shall open anytime the unit is called to run and shall close anytime the unit stops. The exhaust air damper shall close 30 sec (adj.) after the fan stops.
 - b. The fan shall be enabled after the damper status has proven.
 - 4. Monitor:
 - a. Fan status.
 - 5. Alarm:
-

- a. Fan failure - If the exhaust fan is enabled and the fan status is off for more than 30 seconds (adj.), the BMS shall alarm.

J. INLINE EXHAUST FANS

- 1. Unoccupied Mode: Fan shall be disabled in unoccupied mode.
- 2. Occupied Mode: Fan shall be enabled in occupied mode.
- 3. Monitor:
 - a. Fan status.
- 4. Alarm:
 - a. Fan failure - If the exhaust fan is enabled and the fan status is off for more than 30 seconds (adj.), the BMS shall alarm.

K. AIR TERMINAL UNITS

- 1. Single-duct Variable Volume:
 - a. System Description:
 - 1) The VAV air terminal units modulate to provide heating, cooling, and ventilation air flow while the space is occupied. When the space is vacant per the DDC building time clock system, the room will switch to unoccupied mode operation.
 - 2) Minimum scheduled airflows shall be maintained during occupied mode to maintain required ventilation.
 - 3) Primary heating during unoccupied mode shall be by hydronic convector / radiant heating only (where installed) unless set point cannot be maintained.
 - b. Occupied Modes
 - 1) VAV air terminal unit dampers:
 - (a) Modulate to maintain scheduled minimum airflow when occupied.
 - (b) Modulate from minimum to maximum airflow in cooling mode inversely proportional to the deviation between set point and space temperature.
 - (c) Close when vacant.
 - 2) Heating Mode – enable when there is a call for heating.
 - (a) Modulate hydronic reheat pressure independent control valve to maintain occupied heating set point above 70 deg F (adj.).
 - (1) Enable independent space temperature set points for each VAV,
 - (2) Set heating supply air temperature between 78 and 95 deg F (adj.) inversely proportional to the deviation between set point and space temperature.
 - (b) Coordinate with hydronic fin tube where applicable.
 - 3) Cooling Mode – enable when there is a call for space cooling.
 - (a) Maintain occupied temperature below 75 deg F (adj.).
 - (b) Modulate VAV damper above minimum airflow.
 - (c) Modulate hydronic reheat pressure independent control valve to adjust the supply air temperature between 50 and 65 deg F (adj.) inversely proportional to the deviation between set point and space temperature
 - c. Unoccupied Modes
 - 1) VAV air terminal unit dampers:
 - (a) Close the VAV supply damper when there is no call for heating or cooling.

- (b) Open and modulate to maintain unoccupied heating or cooling set point if required. Fin tube heating shall serve as primary heating during vacant periods.
 - 2) Heating Mode.
 - (a) The VAV shall remain closed unless additional heating is required.
 - (b) Fin tube heating shall serve as primary heating during vacant periods.
 - (c) Maintain unoccupied temperature above 60 deg F (adjustable) with fin tube heating as primary heating where equipped.
 - (d) If temperature drops 5 deg. F (adjustable) or more below set point, open the heating hot water control valve to 100% and VAV supply damper to add heating until the space reaches the temperature set point.
 - 3) Cooling Mode – enable when there is a call for cooling and the outdoor air temperature is equal to or above 55°F for a period of 30-minutes (adjustable).
 - (a) Maintain unoccupied temperature below 85 deg. F (adjustable).
- d. Alarms – Provide an alarm for each of the following:
 - 1) Space Temperature low/high limits.
 - 2) VAV airflow low / high limits.
- e. HMI Graphics:
 - 1) Provide a detailed graphic interface of each VAV unit showing all major components such as the VAV damper, control valve, and all associated instrumentation.
 - 2) Display the current state of all components and modes with corresponding set points or operating ranges.
 - 3) Indicate components or instruments that are outside the set point range or state in red flashing background.
 - 4) Provide graphic link to trends and associated data.
 - 5) Coordinate with owner to provide access level lock out regarding ability to make set point changes.
- L. Unit Heaters:
 - 1. Ceiling/Wall Hung Units:
 - a. Heating Mode:
 - 1) When the space temperature falls below the setpoint of 60°F (adjustable), the fan shall be energized and the two-way control valve will modulate to maintain setpoint.
 - 2) When the space setpoint is satisfied, the fan shall be de-energized and the two-way control valve shall close.

END OF SECTION 230993

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**SECTION 232113
HYDRONIC PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic system requirements.
- B. Heating water piping, above grade.
- C. Equipment drains and overflows.
- D. Pipe hangers and supports.
- E. Unions, flanges, mechanical couplings, and dielectric connections.
- F. Valves:
 - 1. Ball valves.
 - 2. Butterfly valves.
 - 3. Check valves.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 230516 - Expansion Fittings and Loops for HVAC Piping.
- C. Section 230719 - HVAC Piping Insulation.
- D. Section 232500 - HVAC Water Treatment: Pipe cleaning.

1.03 REFERENCE STANDARDS

- A. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- D. ASME B31.9 - Building Services Piping; 2025.
- A. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators; 2025, with Errata.
- B. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2024.
- C. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2026.
- D. ASTM A183 - Standard Specification for Carbon Steel Track Bolts and Nuts; 2014 (Reapproved 2020).
- E. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2025.
- F. ASTM A536 - Standard Specification for Ductile Iron Castings; 2024.
- G. ASTM B32 - Standard Specification for Solder Metal; 2020.
- H. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.
- I. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2020.

- J. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2021a.
- K. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications; 2018, with Editorial Revision (2024).
- L. ASTM D2241 - Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series); 2025a.
- M. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40; 2024.
- N. ASTM D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80; 2024.
- O. ASTM D2855 - Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly (Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets; 2020 (Reapproved 2024).
- P. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 2024.
- Q. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications; 2007 (Reapproved 2024).
- R. ASTM F3226/F3226M - Standard Specification for Metallic Press-Connect Fittings for Piping and Tubing Systems; 2019 (Reapproved 2024).
- S. AWS D10.12M/D10.12 - Guide for Welding Mild Steel Pipe; 2000.
- T. AWWA C606 - Grooved and Shouldered Joints; 2022.
- U. IAPMO (UMC) - 2024 Uniform Mechanical Code; 2024.
- V. ICC (IMC) - International Mechanical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- W. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data:
 - 1. Include data on pipe materials, pipe fittings, valves, and accessories.
 - 2. Provide manufacturers catalog information.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.
- B. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- B. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

- A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
- B. Piping: Provide piping, fittings, hangers, and supports as required, as indicated, and as follows:
 - 1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
 - 2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
 - 3. Grooved mechanical joints may be used in accessible locations only.
 - a. Accessible locations include those exposed on interior of building, in pipe chases, and in mechanical rooms, aboveground outdoors, and as approved by Architect.
 - b. Grooved mechanical connections and joints comply with AWWA C606.
 - 1) Ductile Iron: Comply with ASTM A536, Grade 65-45-12.
 - 2) Steel: Comply with ASTM A106/A106M, Grade B or ASTM A53/A53M.
 - c. Use rigid joints unless otherwise indicated.
 - d. Use gaskets of molded synthetic rubber with central cavity, pressure-responsive configuration, and complying with ASTM D2000, Grade 2CA615A15B44F17Z for circulating medium up to maximum 230 degrees F or Grade M3BA610A15B44Z for circulating medium up to maximum 200 degrees F.
 - e. Provide steel coupling nuts and bolts complying with ASTM A183.
 - 4. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
- C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
 - 1. Where grooved joints are used in piping, provide grooved valve/equipment connections if available; if not available, provide flanged ends and grooved flange adapters.
- D. Valves: Provide valves where indicated:
 - 1. Provide drain valves where indicated, and if not indicated, provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate valves with cap; pipe to nearest floor drain.
 - 2. For shut-off and to isolate parts of systems or vertical risers, use ball valves.
 - 3. For throttling service, use plug cocks. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
- E. Welding Materials and Procedures: Comply with ASME BPVC-IX.

2.02 HEATING WATER PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, using one of the following joint types:
 - 1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D10.12M/D10.12 welded.
 - 2. Threaded Joints: ASME B16.3, malleable iron fittings.
 - 3. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
 - 4. Mechanical Press Sealed Fittings: ASTM F3226/F3226M, ICC (IMC), and IAPMO (UMC) approved, with EPDM seals.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn, using one of the following joint types:

1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings.
 - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
2. Grooved Joints: AWWA C606 grooved tube, fittings of same material, and copper-tube-dimension mechanical couplings.
3. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

2.03 EQUIPMENT DRAINS AND OVERFLOWS

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 galvanized; using one of the following joint types:
 1. Threaded Joints: Galvanized cast iron, or ASME B16.3 malleable iron fittings.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn; using one of the following joint types:
 1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
- C. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.
 1. Fittings: ASTM D2466 or D2467, PVC.
 2. Joints: Solvent welded in accordance with ASTM D2855.

2.04 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
 3. Hangers for Cold Pipe Sizes 2 Inches and Greater: Carbon steel, adjustable, clevis.
 4. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
 5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Greater: Steel channels with welded spacers and hanger rods, cast iron roll.
 7. Vertical Support: Steel riser clamp.
 8. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 9. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 10. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 11. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 12. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
- B. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge-shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

2.05 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

- A. Unions for Pipe of 2 Inches and Less:
 1. Ferrous Piping: 150 psi brass or malleable iron, threaded.
 2. Copper Pipe: Bronze, soldered joints.
- B. Flanges for Pipe 2 Inches and Greater:
 1. Ferrous Piping: 150 psig forged steel, slip-on.

2. Gaskets: 1/16 inch thick, preformed neoprene.
- C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
 1. Dimensions and Testing: In accordance with AWWA C606.
 2. Mechanical Couplings: Comply with ASTM F1476.
 3. Housing Material: Ductile iron, galvanized complying with ASTM A536.
 4. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F to 230 degrees F.
 5. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
 6. When pipe is field grooved, provide coupling manufacturer's grooving tools.
 7. Manufacturers:
 - a. Apollo Valves: www.apollovalves.com/#sle.
 - b. Victaulic Company: www.victaulic.com/#sle.
- D. Dielectric Connections:
 1. Waterways:
 - a. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - b. Dry insulation barrier able to withstand 600-volt breakdown test.
 - c. Construct of galvanized steel with threaded end connections to match connecting piping.
 - d. Suitable for the required operating pressures and temperatures.
 2. Flanges:
 - a. Dielectric flanges with same pressure ratings as standard flanges.
 - b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - c. Dry insulation barrier able to withstand 600-volt breakdown test.
 - d. Construct of galvanized steel with threaded end connections to match connecting piping.
 - e. Suitable for the required operating pressures and temperatures.
 3. Unions:
 - a. 1/2 to 1 Inches: Brass solder to galvanized FPT.
 - b. 1/2 to 2 Inches: Brass solder to galvanized FPT.
 - c. 1/2 to 1 Inches: Brass to galvanized FPT or FIP (Female Iron Pipe).
 - d. 3/4 to 1/2 Inch Reducer: Brass solder to galvanized FPT.
 - e. Service: 250 psi, minus 20 to 180 deg F.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment using jointing system specified.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.

- F. After completion, fill, clean, and treat systems. See Section 232500 for additional requirements.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- C. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- D. Install piping to conserve building space and to avoid interference with use of space.
- E. Group piping whenever practical at common elevations.
- F. Sleeve pipe passing through partitions, walls, and floors.
- G. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.
- H. Slope piping and arrange to drain at low points.
- I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. See Section 230516.
- J. Grooved Joints:
 - 1. Install in accordance with the manufacturer's latest published installation instructions.
 - 2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.
- K. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
 - 2. Support horizontal piping as scheduled.
 - 3. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Use hangers with 1-1/2 inches minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 8. Provide copper plated hangers and supports for copper piping.
 - 9. Prime coat exposed steel hangers and supports. See Section 09 9123. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- L. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. See Section 230719.
- M. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welds.
- N. Install valves with stems upright or horizontal, not inverted.

3.03 SCHEDULES

- A. Hanger Spacing for Copper Tubing.
 - 1. 1/2 Inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. 1 Inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.

3. 1-1/2 Inches and 2 Inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
- B. Hanger Spacing for Steel Piping.
 1. 2-1/2 Inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 2. 3 Inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 3. 4 Inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.
 4. 6 Inches: Maximum span, 17 feet; minimum rod size, 1/2 inch.

END OF SECTION 232113

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**SECTION 232114
HYDRONIC SPECIALTIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Shell & tube heat exchangers.
- B. Compression tanks.
- C. Air vents.
- D. Air separators.
- E. Strainers.
- F. Suction diffusers.
- G. Pump connectors.
- H. Pressure-temperature test plugs.
- I. Balancing valves.
- J. Automatic flow control valves.
- K. Pressure reducing valves.

1.02 RELATED REQUIREMENTS

- A. Section 221119 - Domestic Water Piping Specialties: Backflow preventers.
- B. Section 232113 - Hydronic Piping.
- C. Section 232123 - Hydronic Pumps.
- D. Section 232513 - Water Treatment for Closed-Loop Hydronic Systems.

1.03 REFERENCE STANDARDS

- A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2025, with Errata .

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description and model.
- C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- D. Manufacturer's qualification statement.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 SHELL AND TUBE HEAT EXCHANGERS

- A. Manufacturers:
 - 1. Hexonic: www.hexonic.com/#sle.
 - 2. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/#sle.
 - 3. Taco, Inc: www.taco-hvac.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Construction:
 - 1. Heat exchangers shall be ASME rated.
 - 2. Heat exchangers shall be NSF rated.
 - 3. Shell construction:
 - a. Material: 316L stainless steel.
 - b. Thickness: 1.4404 in.
 - 4. Tube construction:
 - a. Material: 316L stainless steel.
 - b. Thickness: 1.4404 in.
 - c. Tubes shall be corrugated type.
 - 5. Maximum design temperature: 329°F (165°C).
 - 6. Maximum design pressure: 232 psi (16 bar).
- C. Connections:
 - 1. Threaded female.

2.02 COMPRESSION TANKS

- A. Manufacturers:
 - 1. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/#sle.
 - 2. Taco, Inc: www.taco-hvac.com/#sle.
 - 3. Amtrol Inc: www.amtrol.com/#sle.
- B. Construction: Closed, welded steel, tested, and stamped in accordance with ASME BPVC-VIII-1; cleaned, prime coated, and supplied with steel support saddles; with tapings for installation of accessories.
 - 1. Pressure Rating: 100 psi.
 - 2. Size: 20 inch diameter, 62 inch overall length, 80 gallon capacity.
- C. Gauge Glass Set: Brass compression stops, guard, and 3/4 inch red line glass, maximum 24 inches length, long enough to cover tank for 2 inches above bottom to 2 inches below top.
- D. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced-pressure-principle backflow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.
 - 1. See Section 221119 for backflow preventer specifications.
- E. Hot Water Heating System:
 - 1. Set pressure reducing valve at 12 psi.

2.03 AIR VENTS

- A. Manufacturers:
 - 1. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/#sle.
 - 2. Taco, Inc: www.taco-hvac.com/#sle.
 - 3. Armstrong International, Inc: www.armstronginternational.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Manual Air Vent: Short vertical sections of 2-inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
- C. Float Air Vent:
 - 1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
- D. Hygroscopic Air Vent:
 - 1. Brass with hygroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring-loaded ball check valve.
- E. Maximum Fluid Pressure: 150 psi.
- F. Maximum Fluid Temperature: 250 degrees F.

2.04 AIR SEPARATORS

- A. Centrifugal Air Separators/Strainers:
 - a. ITT Bell & Gossett.
- 2. Manufacturers:
 - a. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/#sle.
 - b. Taco, Inc: www.taco-hvac.com/#sle.
 - c. Armstrong International, Inc: www.armstronginternational.com/#sle.
 - d. Substitutions: See Section 016000 - Product Requirements.
- 3. Primed steel body, tested and stamped in accordance with ASME BPVC-VIII-1 with integral bronze strainer, tangential flanged inlet and outlet connections, and internal stainless steel air collector tube.
- 4. Maximum Service Flow and Pressure: 16 gpm at 125 psi.

2.05 STRAINERS

- A. Manufacturers:
 - 1. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/#sle.
 - 2. Taco, Inc: www.taco-hvac.com/#sle.
 - 3. The Metraflex Company; LPD Y Strainer: www.metralflex.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Size 2 inch and Under:
 - 1. Provide threaded, grooved, or sweat brass or iron body for up to 175 psi working pressure, Y-pattern strainer with 1/32 inch stainless steel perforated screen.
- C. Size 2-1/2 inch to 4 inch:
 - 1. Provide flanged or grooved iron body for 175 psi working pressure, Y pattern with 1/16 inch or 3/64 inch stainless steel perforated screen.

2.06 SUCTION DIFFUSERS

- A. Manufacturers:

1. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/#sle.
 2. Taco, Inc: www.taco-hvac.com/#sle.
 3. Armstrong International, Inc: www.armstronginternational.com/#sle.
 4. Substitutions: See Section 016000 - Product Requirements.
- B. Suction diffuser manufacturer shall be the same manufacturer as the provided base-mounted pump.
- C. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psi working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable 5/32 inch mesh strainer to fit over cylinder strainer, 20 mesh startup screen, and permanent magnet located in flow stream and removable for cleaning.
- D. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.07 PUMP CONNECTORS

- A. Manufacturers:
1. The Metraflex Company; Vane Flex.
 2. Anvil International; AnviFlex.
 3. Ferguson Enterprises Inc.
 4. Substitutions: See Section 016000 - Product Requirements.
- B. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.
1. Maximum Operating Service: 150 psi at 120 degrees F.
 2. Accommodate the Following:
 - a. Axial Deflection in Compression and Expansion.
 - b. Angular Rotation: 15 degrees.
 - c. Force developed by 1.5 times specified maximum allowable operating pressure.
 3. End Connections: Same as specified for pipe jointing.
 4. Provide necessary accessories including, but not limited to, swivel joints.

2.08 PRESSURE-TEMPERATURE TEST PLUGS

- A. Manufacturers:
1. Ferguson Enterprises Inc.
 2. Peterson Equipment Company Inc.
 3. Sisco Manufacturing Company Inc.
 4. Substitutions: See Section 016000 - Product Requirements.
- B. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and Neoprene rated for minimum 200 degrees F.
- C. Application: Use extended length plugs to clear insulated piping.

2.09 BALANCING VALVES

- A. Manufacturers:
1. ITT Bell & Gossett: www.bellgossett.com/#sle.
 2. Taco, Inc: www.taco-hvac.com/#sle.
 3. Armstrong International, Inc: www.armstronginternational.com/#sle.
- B. Size 2 inch and Smaller:
1. Provide ball or globe style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded or soldered connections.

2. Metal construction materials consist of bronze or brass.
3. Non-metal construction materials consist of Teflon, EPDM, or engineered resin.
- C. Size 2-1/2 inch and Larger:
 1. Provide ball, globe, or butterfly style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged or grooved connections.
 2. Valve body construction materials consist of cast iron, carbon steel, or ductile iron.
 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, NORYL, or engineered resin.

2.10 AUTOMATIC FLOW CONTROL VALVES

- A. Construction:
 1. Brass, bronze, or iron body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet with blowdown/backflush drain.
 2. Built-in lug-type outlet butterfly valve with 2-position handle.
- B. Calibration: Control flow within 10 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, minimum pressure 2 psi.
- C. Control Mechanism: Provide stainless steel or nickel-plated, brass piston or regulator cup, operating against stainless steel helical or wave formed spring or elastomeric diaphragm and polyphenylsulfone orifice plate.

2.11 PRESSURE REDUCING VALVES

- A. Manufacturers:
 1. ITT Bell & Gossett: www.bellgossett.com/#sle.
 2. Taco, Inc: www.taco-hvac.com/#sle.
 3. Armstrong International, Inc: www.armstronginternational.com/#sle.
 4. Substitutions: See Section 016000 - Product Requirements.
- B. Operation: Automatically feeds make-up water to the hydronic system whenever pressure in the system drops below the pressure setting of the valve. Refer to Section 232113.
- C. Materials of Construction:
 1. Valve Body: Constructed of bronze, cast iron, brass, or iron.
 2. Internal Components: Construct of stainless steel or brass and composition material.
- D. Connections:
- E. Provide integral check valve and strainer.
- F. Maximum Inlet Pressure: 400 psi.
- G. Maximum Fluid Temperature: 180 degrees F.
- H. Adjustable Pressure Range: From 10 to 45 psi, set to 25 psi.

2.12 AUTOMATIC FLOW CONTROL VALVES

- A. Manufacturers:
 1. ITT Bell & Gossett: www.bellgossett.com/#sle.
 2. Taco, Inc: www.taco-hvac.com/#sle.
 3. Armstrong International, Inc: www.armstronginternational.com/#sle.
 4. Substitutions: See Section 016000 - Product Requirements.
- B. Size 1/2 inch to 14 inch:

1. Provide ball or globe style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded or soldered connections.
 2. Metal construction materials consist of bronze or brass.
 3. Non-metal construction materials consist of Teflon, EPDM, or engineered resin.
- C. Size 2-1/2 inch to 24 inch:
1. Provide ball, globe, butterfly, or wafer style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged or grooved connections.
 2. Valve body construction materials consist of cast iron, carbon steel, ductile iron, or gray iron.
 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, NORYL, or engineered resin.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install specialties and equipment in accordance with manufacturer's instructions.
- B. Provide manual air vents at system high points and as indicated.
- C. Provide manual air vents in ceiling spaces and other concealed location
- D. Provide automatic air vents in exposed locations and in mechanical rooms.
- E. Provide valved drain and hose connection on strainer blowdown connection.
- F. Support pump fittings with floor-mounted pipe and flange supports.
- G. Provide relief valves on pressure tanks, low-pressure side of reducing valves, heat exchangers, and expansion tanks.
- H. Pipe relief valve outlet to nearest floor drain.

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.

3.03 MAINTENANCE

- A. See Section 017000 - Execution Requirements for additional requirements relating to maintenance service.
- B. Perform monthly visit to make glycol fluid concentration analysis on site with refractive index measurement instrument. Report findings in detail in writing, including analysis and amounts of glycol or water added.
- C. Explain corrective actions to Owner's maintenance personnel in person.

END OF SECTION 232114

**SECTION 232123
HYDRONIC PUMPS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Circulators.
- B. In-line pumps.
 - 1. Heating hot water pumps.
 - 2. Pool water pumps.
- C. End-suction pumps.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 230513 - Common Motor Requirements for HVAC Equipment.
- C. Section 230548 - Vibration and Seismic Controls for HVAC.
- D. Section 230719 - HVAC Piping Insulation.
- E. Section 230923 - Direct-Digital Control System for HVAC.
- F. Section 230934 - Variable-Frequency Motor Controllers.
- G. Section 232113 - Hydronic Piping.
- H. Section 232114 - Hydronic Specialties.
- I. Section 253500 - Integrated Automation Instrumentation and Terminal Devices for HVAC.

1.03 REFERENCE STANDARDS

- A. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.
- D. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.
 - 2. Extra Pump Seals: One set for each type and size of pump.

1.05 QUALITY ASSURANCE

- A. Equipment manufacturer shall be a company specializing in manufacture, assembly, and field performance of provided equipment with a minimum of 20 years experience.

- B. Equipment provider shall be responsible for providing certified equipment start-up and, when noted, an in the field certified training session. New pump start-up shall be for the purpose of determining pump alignment, lubrication, voltage, and amperage readings. All proper electrical connections, pump's balance, discharge and suction gauge readings, and adjustment of head, if required. A copy of the start-up report shall be made and sent to both the contractor and to the Engineer.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the site in such a manner as to protect the materials from shipping and handling damage. Provide materials on factory provided shipping skids and lifting lugs if required for handling. Materials damaged by the elements should be packaged in such a manner that they could withstand short-term exposure to the elements during transportation.
- B. Store materials in clean, dry place and protect from weather and construction traffic. Handle carefully to avoid damage.
- C. Use all means necessary to protect equipment before, during, and after installation.
- D. All scratched, dented, and otherwise damaged units shall be repaired or replaced as directed by the Architect/Engineer.

1.07 WARRANTY

- A. Provide a minimum One (1) year warranty on materials and installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Bell & Gossett, a Xylem Inc. brand: www.bellgossett.com/#sle.
- B. Taco Comfort Solutions: www.tacomfort.com/#sle.
- C. Armstrong Fluid Technology, Inc: www.armstrongfluidtechnology.com/#sle.
- D. Substitutions: See Section 016000 - Product Requirements.

2.02 GENERAL

- A. Provide pumps that operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
- B. Electrical Requirements:
 - 1. Listed and classified by UL or testing agency acceptable to authority having jurisdiction as suitable for the purpose specified and indicated.
 - 2. Variable Frequency Drives (VFDs):
 - a. Drives shall be furnished by the Division 23 contractor, and installed by Division 26.
 - 3. Enclosures: Provide unspecified product(s) required to fit motor:

2.03 CIRCULATORS

- A. Horizontal shaft, single-stage pump with direct connected, resilient-mount, oil lubricated motor for discharge pressures of up to 125 psi.
- B. Casing: Cast iron, with flanged pump connections.
- C. Impeller: Non-ferrous keyed to shaft.
- D. Bearings: Oil-lubricated bronze sleeve.
- E. Shaft: Alloy steel with bronze sleeve, integral thrust collar.

- F. Seal: Mechanical seal, 225 degrees F maximum continuous duty temperature.
- G. Drive: Flexible coupling.

2.04 IN-LINE PUMPS

- A. Heating Hot Water In-line Pumps:
 - 1. The pumps shall be of the horizontal, permanently lubricated type, specifically designed and guaranteed for quiet operation.
 - 2. The pumps shall have a steel shaft supported by permanently lubricated, sealed precision ball bearings. The pumps are to be equipped with a water-tight seal to prevent leakage. Mechanical seal faces to be carbon on silicon carbide. The motor shall be non-overloading at any point on the pump performance curve.
 - 3. The motor shall be of the drip-proof, sealed precision ballbearing, quiet-operating construction. The permanent splitcapacitor motor shall be equipped with thermal overload protection.
 - 4. Casing: Cast iron with seal flush connection, threaded suction, and discharge ports with gauge port and drain plug.
 - 5. Impeller: Bronze, fully enclosed, keyed directly to motor shaft or extension.
 - 6. Shaft: Carbon steel with stainless steel impeller cap screw or nut.
 - 7. Seal: Mechanical seal, 225 degrees F maximum continuous duty temperature.
- B. Pool Water Pumps:
 - 1. Manufacturers:
 - a. Goulds Pumps, a Xylem Inc. brand: www.gouldspumps.com/#sle.
 - b. Bell & Gossett, a Xylem Inc. brand: www.bellgossett.com/#sle.
 - c. Grundfos Pumps Corporation: www.grundfos.com/us/#sle.
 - d. Substitutions: See Section 016000 - Product Requirements.
 - 2. General Requirements:
 - a. Maximum working temperature: 212°F.
 - b. Maximum working pressure: 125 PSIG.
 - 3. Casing:
 - a. The pump casing shall be concentric volute, diffuser type, back pull-out design with NPT suction and discharge connections and shall be constructed of AISI TYPE 316 stainless steel material.
 - b. The pump discharge shall be center line oriented to allow simplified system design and installation.
 - c. The complete pump unit shall be supported by the power frame.
 - d. Pump casing vent/fill and drain shall be provided with stainless steel plugs.
 - 4. Floating Suction O-Ring:
 - a. The pump shall be provided with an easily replaceable suction O-ring, pumpage lubricated and self-aligning to maintain maximum pump efficiency without adjustment of impeller clearances.
 - 5. Impeller:
 - a. The impeller shall be of enclosed design, constructed of AISI TYPE 316 stainless steel material, threaded shaft connection secured with lock nut.
 - 6. Seal Housing:
 - a. The seal housing shall be self-flushing design, constructed of AISI TYPE 316 stainless steel material and shall hold the stationary seat of the mechanical shaft seal.

- b. The seal housing shall be clamped in place over a machined fit on the power frame adapter by the pump casing to maintain component alignment and "O-ring" sealed to insure against leakage.
- 7. Power Frame Adapter:
 - a. Adapter shall be constructed of AISI Type 316 stainless steel and support the pump liquid end and maintain pump to power frame alignment. A bottom port shall be provided to allow condensation or seal leakage to drain and not be retained within the adapter.
- 8. Power Frame Assembly:
 - a. The pump shall be supported by means of a foot mounted, cast iron ASTM A 48 CL20 or equal power frame which carries all thrust and radial loads imposed by the pump with a minimum B-10 life of 20,000 hours.
 - b. Bearings:
 - 1) Ball type "greased for life" double shielded thrust and radial bearings. The outboard bearing shall carry all pump thrust load, and shall be held in place on the pump shaft by means of a retaining ring.
 - c. Pump Shaft:
 - 1) The wetted pump shaft shall be constructed of AISI Type 316 stainless steel.
 - d. Bearing Assembly & Shaft Seals:
 - 1) Both inboard and outboard ball bearings shall be protected from entry of washdown water or grit by means of Buna-N lip seals.
 - e. Bearing Cover:
 - 1) The shaft and bearing assembly shall be locked in position by an outboard bearing cover constructed of ASTM A48 CL20 cast iron or equal.
- 9. Bedplate:
 - a. A rigid steel bedplate shall be provided to maintain support and alignment of the complete pump and motor assembly. Bedplate shall be suitable for anchor bolt wall mounting and include provision for grouting.
- 10. Drive Coupling:
 - a. A spacer type coupling allowing utilization of back pullout maintenance feature shall be provided for pump to motor connection.
 - b. The coupling shall be key driven T.B. Woods type "SC" or equal.
- 11. Coupling Guard:
 - a. All rotating components of the drive assembly shall be protected by means of a formed metal coupling guard, designed to OSHA specifications.
- 12. Pool pumps shall be NSF rated.

2.05 END-SUCTION PUMPS

- A. Description:
 - 1. The pumps shall be long coupled, base mounted, single stage, end suction, vertical split case design, in cast iron stainless steel fitted, specifically designed for quiet operation.
 - 2. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupling.
- B. Casing: Cast iron with renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction, and discharge flanged connections with gauge ports.
- C. Impeller: Stainless steel, balanced, fully enclosed, keyed to shaft.
- D. Bearings:

1. A bearing assembly shall support the shaft via two heavy-duty regreaseable ball bearings. Bearing assembly shall be replaceable without disturbing the system piping and shall have foot support at the coupling end. Pump bearings shall be regreaseable without removal of the bearings from the bearing assembly. Thermal expansion of the shaft toward the impeller shall be prevented via an inboard thrust bearing.
 2. The bearing assembly shall have a solid SAE1144 steel shaft. A stainless steel shaft sleeve shall be employed to completely cover the wetted area under the seal.
- E. Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.
- F. Drive: Flexible coupling with coupling guard.
- G. Motors:
1. Pump and motors shall be factory aligned, and shall be realigned after installation by the manufacturer's representative. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications and conform to standards outlined in EISA 2007.
- H. Baseplate:
1. Base plate shall be of structural steel or fabricated steel channel configuration fully enclosed at sides and ends, with securely welded cross members and fully open grouting area (for field grouting). The minimum base plate stiffness shall conform to ANSI/HI 1.3.8.2.1-2019 for grouted Horizontal Baseplate Design standards.

PART 3 EXECUTION

3.01 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.
- C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close-coupled or base-mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over.
- D. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
- E. Provide air cock and drain connection on horizontal pump casings.
- F. Provide drains for bases and seals, piped to and discharging into floor drains.
- G. Check, align, and certify alignment of base-mounted pumps prior to start-up.
- H. Install close-coupled and base-mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. See Section 033000.
- I. Lubricate pumps before start-up.
- J. Controls: Interface each pump starter or VFD with HVAC controller; see Section 230923.
- K. Controls Human-Machine Interface (HMI): HVAC operator terminal; see Section 253500.
- L. All piping shall be brought to equipment and pump connections in such a manner so as to prevent the possibility of any loads or stresses being applied to the connections or piping. All

pipng shall be fitted to the pumps even though piping adjustments may be required after the pipe is installed.

3.03 TESTING (POOL PUMPS ONLY)

- A. Production performance testing will be conducted by the manufacturer on each pump unit. Head at shut off and a minimum of 2 operating points will be measured at design speed to verify performance.

END OF SECTION 232123

**SECTION 232300
REFRIGERANT PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.
- F. Check valves.
- G. Filter-driers.
- H. Solenoid valves.
- I. Expansion valves.
- J. Exterior penetration accessories.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 230719 - HVAC Piping Insulation.

1.03 REFERENCE STANDARDS

- A. AHRI 760 (I-P) - Performance Rating of Solenoid Valves for Use with Volatile Refrigerants; 2014.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2024, with Addendum (2026).
- C. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants; 2024, with Addendum (2025).
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- E. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes; 2024.
- F. ASME B31.5 - Refrigeration Piping and Heat Transfer Components; 2022.
- G. ASME B31.9 - Building Services Piping; 2025.
- H. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2024.
- I. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.
- J. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2020.
- K. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service; 2023.
- L. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.
- M. IAPMO (UMC) - 2024 Uniform Mechanical Code; 2024.
- N. ICC (IMC) - International Mechanical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

- O. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2025.
- P. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical; Current Edition, Including All Revisions.
- Q. UL 429 - Electrically Operated Valves; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- C. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties in shipping containers with labeling in place.
- B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

- A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure integrity of system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Provide pipe hangers and supports in accordance with ASME B31.5 unless indicated otherwise.
- C. Valves:
 - 1. Use service valves on suction and discharge of compressors.
- D. Strainers:
 - 1. Where multiple expansion valves with integral strainers are used, use single main liquid line strainer.
- E. Filter-Driers:
 - 1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.
- F. Solenoid Valves:

2.02 REGULATORY REQUIREMENTS

- A. Comply with ASME B31.9 for installation of piping system.

2.03 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn.
 - 1. Fittings: ASME B16.22 wrought copper.
 - 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.
- B. Copper Tube to 7/8-inch OD: ASTM B88 (ASTM B88M), Type K (A), annealed.
 - 1. Fittings: ASME B16.26 cast copper.

2. Joints: Flared.
3. Mechanical Press Fittings: UL 207 listed, ICC (IMC) and IAPMO (UMC) approved, with HNBR seals.
- C. Pipe Supports and Anchors:
 1. Provide hangers and supports complying with MSS SP-58.
 - a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron adjustable swivel, split ring.
 3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
 4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 6. Vertical Support: Steel riser clamp.
 7. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 8. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 9. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
 10. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
 - a. Bases: High density, UV tolerant, polypropylene or reinforced PVC.
 - b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
 - d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
 - e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.

2.04 REFRIGERANT

- A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) no greater than that allowed by federal code.

2.05 MOISTURE AND LIQUID INDICATORS

- A. Indicators: Single port type, UL listed, with copper or brass body, flared or soldered ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum temperature of 200 degrees F and maximum working pressure of 500 psi.

2.06 VALVES

- A. Service Valves:
 1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or soldered ends, for maximum pressure of 500 psi.

2.07 STRAINERS

- A. Straight Line or Angle Line Type:
 1. Brass or steel shell, steel cap and flange, and replaceable cartridge, with screen of stainless steel wire or monel reinforced with brass; for maximum working pressure of 430 psi.

2.08 CHECK VALVES

- A. Globe Type:
 - 1. Cast bronze or forged brass body, forged brass cap with neoprene seal, brass guide and disc holder, phosphor-bronze or stainless steel spring, teflon seat disc; for maximum temperature of 300 degrees F and maximum working pressure of 425 psi.
- B. Straight Through Type:
 - 1. Brass body and disc, phosphor-bronze or stainless steel spring, neoprene seat; for maximum working pressure of 500 psi and maximum temperature of 200 degrees F.

2.09 FILTER-DRIERS

- A. Performance:
 - 1. Pressure Drop: 2 psi, maximum, when operating at full connected evaporator capacity.
 - 2. Design Working Pressure: 350 psi, minimum.
- B. Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, activated charcoal, and filtration to 40 microns, with secondary filtration to 20 microns; of construction that will not pass into refrigerant lines.
- C. Construction: UL listed.
 - 1. Connections: As specified for applicable pipe type.

2.10 SOLENOID VALVES

- A. Valve: AHRI 760 (I-P), pilot operated, copper, brass or steel body and internal parts, synthetic seat, stainless steel stem and plunger assembly (permitting manual operation in case of coil failure), integral strainer, with flared, soldered, or threaded ends; for maximum working pressure of 500 psi.
- B. Coil Assembly: UL 429 UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color coded lead wires, integral junction box with pilot light.

2.11 EXPANSION VALVES

- A. Angle or Straight Through Type: AHRI 760 (I-P); design suitable for refrigerant, brass body, internal or external equalizer, bleed hole, adjustable superheat setting, replaceable inlet strainer, with nonreplaceable capillary tube and remote sensing bulb and remote bulb well.
- B. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select to avoid being undersized at full load and excessively oversized at part load.

2.12 CONDUIT AND SUPPORT FOR PIPING

- A. Commercial, Protective Conduit:
 - 1. Manufacturers:
 - a. RectorSeal: www.rectorseal.com.
 - b. Inaba Denko America Inc; PD Series Commercial PVC: www.inabadenko-america.com/#sle.
 - c. Substitutions: See Section 016000 - Product Requirements.
 - 2. Description: Conduit for concealing and protecting piping; suitable for indoor or outdoor installation; UV- and weather-resistant to protect piping from damage and exposure. Includes couplers, fittings, steel mounting brackets and supports to conceal and support piping.
 - 3. Construction: Plastic exterior with rigid, flame-retardant straight runs.

4. Temperature: Surface rated for temperatures 0 degrees F to 130 degrees F.
 5. Color: To be selected by Architect from manufacturer's standard range.
 6. Dimensions: Houses entire lineset of refrigerant piping and drain hose as shown on drawings. Available in inner diameter sizes from 3-1/2 inches or smaller to 4-3/4 inches or larger.
- B. Heavy-Duty, Protective Multi-Lineset Enclosure:
1. Manufacturers:
 - a. Inaba Denko America Inc; Slimduct RD Metal Lineset Cover: www.inabadenko-america.com/#sle.
 - b. Substitutions: See Section 016000 - Product Requirements.
 2. Description: Rigid encasement to cover and enclose multiple linesets; suitable for outdoor and rooftop applications; provides protection against impact force and weather; installs on both horizontal and vertical piping.
 3. Construction: Metal exterior; weather-, corrosion-, and salt-resistant.
 - a. Coating: Layer of zinc chemical mixture applied to exterior for corrosion resistance.
 4. Tensile Strength: 30 psf or greater.
 5. Load Rating: Cover provides resistance to loads up to 100 psf or greater.

2.13

2.14 EXTERIOR PENETRATION ACCESSORIES

- A. Sealing Systems for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for linesets and facade materials to be installed.
- B. Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for linesets and roofing system to be installed; designed to accommodate existing penetrations where applicable.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.02 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Inserts:
 1. Provide inserts for placement in concrete formwork.

2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- G. Pipe Hangers and Supports:
1. Install in accordance with ASME B31.5.
 2. Support horizontal piping as indicated.
 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 4. Place hangers within 12 inches of each horizontal elbow.
 5. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
 6. Provide copper plated hangers and supports for copper piping.
- H. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- I. Provide clearance for installation of insulation and access to valves and fittings.
- J. Flood piping system with nitrogen when brazing.
- K. Insulate piping and equipment.
- L. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
- M. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
- N. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- O. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
- P. Fully charge completed system with refrigerant after testing.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Test refrigeration system in accordance with ASME B31.5.
- C. Pressure test system with dry nitrogen to 200 psi. Perform final tests at 27 inches vacuum and 200 psi using halide torch. Test to no leakage.

3.04 SCHEDULES

- A. Hanger Spacing for Copper Tubing.
 1. 1/2 inch, 5/8 inch, and 7/8 inch OD: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 2. 1-1/8 inch OD: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 3. 1-3/8 inch OD: Maximum span, 7 feet; minimum rod size, 3/8 inch.
 4. 1-5/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 5. 2-1/8 inch OD: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 6. 2-5/8 inch OD: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 7. 3-1/8 inch OD: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 8. 3-5/8 inch OD: Maximum span, 11 feet; minimum rod size, 1/2 inch.

END OF SECTION 232300

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**SECTION 232513
WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS**

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes water treatment for closed-loop hydronic systems.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Pretreatment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to hydronic systems.

1.03 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For components, from manufacturer.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- E. Water Analysis: Illustrate water quality available at Project site.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.05 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 PRODUCTS

2.01 BYPASS (POT) FEEDERS

- 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. J.L. Wingert Company: www.jlwingert.com/#sle.
 - 2. Wessels Company: www.westank.com/#sle.
 - 3. Aqua-Chem, Inc: www.aqua-chem.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Manufacturer requirements:
 - 1. 5 gallon quick opening cap for working pressure of 200 psi and a maximum temperature of 250 degrees F.
- C. Construction:
 - 1. Closure: Cast Iron.
 - 2. Body: Carbon Steel.
 - 3. Basket: 304 stainless steel.
- D. Accessories:

1. Filter: 25 microns.
2. Provide with additional filters from manufacturer.
3. Provide with manufacturer recommended support stand.

2.02 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

2.03 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and able to attain water quality specified in "Performance Requirements" Article.

PART 3 EXECUTION**3.01 WATER ANALYSIS**

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.02 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drain.
- B. Install interconnecting control wiring for chemical-treatment controls and sensors.
- C. Mount sensors and injectors in piping circuits.
- D. Bypass Feeders: Install in closed hydronic systems, including glycol heating, and equip with the following:
 1. Install bypass feeder in a bypass circuit around circulating pumps unless indicated otherwise on Drawings.
 2. Install water meter in makeup-water supply.
 3. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 4. Install a swing check on the inlet after the isolation valve.
- E. Install automatic fluid make-up equipment for glycol water system, and include the following:
 1. Chemical solution tanks.
 2. Chemical solution injection pumps.
 3. Water meter in makeup supply to system.
 4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

3.03 PIPING CONNECTIONS

- A. Piping installation requirement are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves For HVAC Piping".

3.04 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections with the assistance of a factory-authorized service representative.
- E. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. 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 test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- F. Equipment will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.
- I. Comply with ASTM D3370 and with the following standards:
 - 1. Silica: ASTM D859.
 - 2. Acidity and Alkalinity: ASTM D1067.
 - 3. Iron: ASTM D1068.

4. Water Hardness: ASTM D1126.

3.05 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion and scale formation for hydronic piping and equipment.
- B. Coordinate with the Owners Representative for desired chemical treatment service provider.
- C. Services and chemicals shall be provided for a period of **ONE YEAR** from date of Substantial Completion and shall include the following:
 - 1. Initial water analysis and HVAC water-treatment recommendations.
 - 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 - 3. Periodic field service and consultation.
 - 4. Customer report charts and log sheets.
 - 5. Laboratory technical analysis.
 - 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232513

**SECTION 233100
HVAC DUCTS AND CASINGS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal ducts.
- B. Air plenums and casings.
- C. Ducts for dryer exhaust.

1.02 RELATED REQUIREMENTS

- A. Section 230130.51 - HVAC Air-Distribution System Cleaning: Post install duct cleaning.
- B. Section 230713 - Duct Insulation: External insulation and duct liner.
- C. Section 233300 - Air Duct Accessories.
- D. Section 233319 - Duct Silencers.
- E. Section 233700 - Air Outlets and Inlets: Fabric air distribution devices.

1.03 REFERENCE STANDARDS

- A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; Most Recent Edition Cited by Referring Code or Reference Standard.
- B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.
- C. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2025a.
- D. ASTM A666/A666M - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar; 2024.
- E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- F. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements; 2015.
- G. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry; 2018, with Editorial Revision (2020).
- H. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements; 2017, with Editorial Revision (2020).
- I. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements; 2023.
- J. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- K. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- L. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; 2012.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for duct materials.
- C. Shop Drawings: Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work for B pressure class and higher systems.

- D. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate per appropriate seal class, following SMACNA (LEAK).

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience, and approved by manufacturer.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Provide UL Class 1 ductwork, fittings, hangers, supports, and appurtenances in accordance with NFPA 90A and SMACNA (DCS) guidelines unless stated otherwise.
- B. Provide metal duct unless otherwise indicated. Fibrous glass duct can be substituted at the Contractor's option.
- C. Acoustical Treatment: Provide sound-absorbing liners and sectional silencers for metal-based ducts in compliance with Section 233319.
- D. Duct Shape and Material in accordance with Allowed Static Pressure Range:
1. Round: Plus or minus 2 in-wc of galvanized steel.
 2. Rectangular: Plus or minus 1/2 in-wc of galvanized steel.
- E. Duct Sealing and Leakage in accordance with Static Pressure Class:
1. Duct Pressure Class and Material for Common Mechanical Ventilation Applications:
 - a. Supply Air: 1/2 in-wc pressure class, galvanized steel.
 - b. Outside Air Intake: 1/2 in-wc pressure class, galvanized steel.
 - c. Return and Relief Air: 1/2 in-wc pressure class, galvanized steel.
 - d. General Exhaust Air: 1/2 in-wc pressure class, galvanized steel.
 - e. Pool Supply Air: 1/2 in-wc pressure class, stainless steel.
 - f. Pool Return Air: 1/2 in-wc pressure class, stainless steel.
 - g. Pool Exhaust Air: 1/2 in-wc pressure class, stainless steel.
 - h. Transfer Air: 1/2 in-wc pressure class, galvanized steel.
- F. Duct Fabrication Requirements:
1. Duct and Fitting Fabrication and Support: SMACNA (DCS) including specifics for continuously welded round and oval duct fittings.
 2. Use reinforced and sealed sheet-metal materials at recommended gauges for indicated operating pressures or pressure class.
 3. Construct tees, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide airfoil turning vanes of perforated metal with glass fiber insulation.
 4. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.
 5. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
 6. Provide turning vanes of perforated metal with glass fiber insulation when an acoustical lining is required.
 7. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.02 METAL DUCTS

- A. Material Requirements:
 - 1. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.
 - 2. Pool ductwork:
 - a. Stainless Steel: ASTM A666, Type 304.

2.03 AIR PLENUMS AND CASINGS

- A. Fabricate in accordance with SMACNA (DCS) for indicated operating pressures indicated.
- B. Minimum Fabrication Requirements:
 - 1. Fabricate acoustic plenum or casing with reinforcing turned inward.
 - 2. Provide 16-gauge, 0.059-inch sheet steel back facing and 22-gauge, 0.029-inch perforated sheet steel front facing with 3/32 inch diameter holes on 5/32 inch centers.
 - 3. Construct panels 3 inches thick, packed with 4.5 pcf minimum glass fiber insulation media, on inverted channel of 16-gauge, 0.059-inch sheet steel.
 - 4. Mount floor-mounted plenum or casings on 4-inch high concrete curbs. At floor, rivet panels on 8-inch centers to angles. Where floors are acoustically insulated, provide liner of galvanized 18-gauge, 0.052-inch expanded metal mesh supported at 12-inch centers, turned up 12 inches at sides with sheet metal shields.
- C. Access Doors:
 - 1. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection.
 - 2. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles.
 - 3. Provide clear wire glass observation ports, minimum 6 by 6 inch size.

2.04 DUCTS FOR DRYER EXHAUST

- A. Material Requirements:
 - 1. Exhaust Duct shall be constructed of galvanized steel.
 - 2. Exhaust ducts shall have a smooth interior finish and shall be constructed of metal not less than 0.016 inch (0.4 mm) in thickness.
 - 3. The exhaust duct size shall be 4 inches (102 mm) nominal in diameter.
- B. Roof Termination Kit:
 - 1. Manufacturers:
 - a. RoofGooseJack; www.roofgoosevent.com/#sle.
 - 1) Model Number: RJ4 - Dryer
 - b. Substitutions: See Section 016000 - Product Requirements.
- C. Flexible duct is not permitted.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install products following the manufacturer's instructions.
- C. During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering the ductwork system.
- D. Flexible Ducts: Connect to metal ducts with adhesive.

- E. Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.
- F. Provide openings in ductwork as indicated to accommodate thermometers and controllers. Provide pilot tube openings as indicated for testing of systems, complete with metal can with spring device or screw to insure against air leakage. For openings, insulate ductwork and install insulation material inside a metal ring.
- G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- H. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with a crimp in the direction of airflow.
- I. Use double nuts and lock washers on threaded rod supports.
- J. Connect terminal units to supply ducts directly or with one foot maximum length of flexible duct. Do not use flexible duct to change direction.
- K. Connect diffusers or light troffer boots to low-pressure ducts directly or with 5 feet maximum length of flexible duct held in place with strap or clamp.
- L. Dryer Exhaust Ductwork:
 - 1. Dryer exhaust ductwork shall be installed in accordance with the manufacturer's instructions.
 - 2. Where dryer exhaust ducts are enclosed in wall or ceiling cavities, such cavities shall allow the installation of the duct without deformation.
 - 3. Transition ducts used to connect the dryer to the exhaust duct system shall be a single length that is listed and labeled in accordance with UL 2158A. Transition ducts shall be not greater than 8 feet (2438 mm) in length and shall not be concealed within construction.
 - 4. Exhaust ducts shall be supported at 4-foot (1219 mm) intervals and secured in place. The insert end of the duct shall extend into the adjoining duct or fitting in the direction of airflow. Ducts shall not be joined with screws or similar fasteners that protrude more than 1/8 inch (3.2 mm) into the inside of the duct.
 - 5. Protective shield plates shall be placed where nails or screws from finish or other work are likely to penetrate the clothes dryer exhaust duct. Shield plates shall be placed on the finished face of all framing members where there is less than 1 1/4 inches (32 mm) between the duct and the finished face of the framing member. Protective shield plates shall extend not less than 2 inches (51 mm) above sole plates and below top plates.
 - a. Shield plates shall be of steel material having a thickness of not less than 0.0575 inch (1.463 mm) (No. 16 gage).
 - 6. Where the exhaust duct equivalent length exceeds 35 feet (10668 mm), the equivalent length of the exhaust duct shall be identified on a permanent label or tag. The label or tag shall be located within 6 feet (1829 mm) of the exhaust duct connection.
 - 7. Each vertical riser shall be provided with a means for cleanout.

3.02 CLEANING

- A. Clean thoroughly each duct system. See Section 230130.51.
- B. Clean duct system by forcing air at high velocity through duct to remove accumulated dust. Clean half the system at a time to obtain sufficient air. Protect equipment that could be harmed by excessive dirt with temporary filters or bypass during cleaning.

END OF SECTION 233100

**SECTION 233300
AIR DUCT ACCESSORIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air turning devices/extractors.
- B. Combination fire and smoke dampers - corridor dampers.
- C. Duct access doors.
- D. Duct test holes.
- E. Fire dampers.
- F. Flexible duct connectors.
- G. Volume control dampers.
- H. Miscellaneous Products:
 - 1. Damper operators.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 233100 - HVAC Ducts and Casings.
- C. Section 253513 - Integrated Automation Actuators and Operators: Damper operators.

1.03 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- B. NFPA 92 - Standard for Smoke Control Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- D. UL 33 - Safety Heat Responsive Links for Fire-Protection Service; Current Edition, Including All Revisions.
- E. UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.
- F. UL 555S - Standard for Smoke Dampers; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide for shop fabricated assemblies including volume control dampers, duct access doors, duct test holes, and hardware used. Include electrical characteristics and connection requirements.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements for additional provisions.
 - 2. Extra Fusible Links: One of each type and size.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

2.01 AIR TURNING DEVICES/EXTRACTORS

- A. Manufacturers:
 - 1. Carlisle HVAC Products; Dynair Hollow Vane and Rail (Double Wall Vane): www.carlislehvac.com/#sle.
 - 2. Krueger-HVAC, Division of Air System Components: www.krueger-hvac.com/#sle.
 - 3. Titus HVAC, a brand of Johnson Controls: www.titus-hvac.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Multi-blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.

2.02 COMBINATION FIRE AND SMOKE DAMPERS - CORRIDOR DAMPERS

- A. Manufacturers:
 - 1. Ruskin Company: www.ruskin.com/#sle.
 - 2. United Enertech: www.unitedenertech.com/#sle.
 - 3. Nailor Industries, Inc: www.nailor.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Provide factory sleeve and collar for each damper.
- D. Multiple Blade Dampers: Fabricate with 16 gauge, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- E. Operators: UL listed and labeled; spring-return, electric type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on interior of duct and link to damper operating shaft.
- F. Normally Closed Smoke Responsive Fire Dampers: Curtain type, opening by gravity upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure.
- G. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.03 DUCT ACCESS DOORS

- A. Manufacturers:
 - 1. Ductmate Industries, Inc, a DMI Company: www.ductmate.com/#sle.
 - 2. Nailor Industries, Inc: www.nailor.com/#sle.
 - 3. Ruskin Company: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Access doors with sheet metal screw fasteners are not acceptable.

2.04 DUCT TEST HOLES

- A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

2.05 FIRE DAMPERS

- A. Manufacturers:
 - 1. Lloyd Industries, Inc: www.firedamper.com/#sle.
 - 2. Nailor Industries, Inc: www.nailor.com/#sle.
 - 3. Ruskin Company: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- C. Horizontal Dampers: Galvanized steel, 22-gauge, 0.0299-inch frame, stainless steel closure spring, and lightweight, heat-retardant, non-asbestos fabric blanket.
- D. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for 1-inch pressure-class ducts up to 12 inches in height.
- E. Fusible Links: UL 33, separate at 160 degrees F with adjustable link straps for combination fire/balancing dampers.

2.06 FLEXIBLE DUCT CONNECTORS

- A. Manufacturers:
 - 1. Carlisle HVAC Products; Dynair Connector Plus G90 Steel Offset Seam Neoprene Fabric: www.carlislehvac.com/#sle.
 - 2. Ductmate Industries, Inc, a DMI Company: www.ductmate.com/#sle.
 - 3. Elgen Manufacturing Company, Inc: www.elgenmfg.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Flexible Duct Connections: Fabric crimped into metal edging strip.
- D. Maximum Installed Length: 14 inch.

2.07 VOLUME CONTROL DAMPERS

- A. Manufacturers:
 - 1. Louvers & Dampers, Inc, a brand of Mestek, Inc: www.louvers-dampers.com/#sle.
 - 2. Nailor Industries, Inc: www.nailor.com/#sle.
 - 3. Ruskin Company: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Single Blade Dampers:
 - 1. Fabricate for duct sizes up to 6 by 30 inch.
 - 2. Blade: 24 gauge, 0.0239 inch, minimum.
- D. Multi-Blade Damper: Fabricate consisting of opposed blades with maximum blade sizes 8 by 72 inches. Assemble center- and edge-crimped blades in prime-coated or galvanized-channel frame with suitable hardware.
 - 1. Blade: 18 gauge, 0.0478 inch, minimum.

- E. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.

2.08 MISCELLANEOUS PRODUCTS

- A. Damper Operators: Provide electric operators; see Section 253513.

PART 3 EXECUTION

3.01 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.02 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). See Section 233100 for duct construction and pressure class.
- B. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide minimum 8 by 8 inch size for hand access, size for shoulder access, and as indicated. Provide 4 by 4 inch for balancing dampers only. Review locations prior to fabrication.
- C. Provide duct test holes where indicated and required for testing and balancing purposes.
- D. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
- E. Demonstrate re-setting of fire dampers to Owner's representative.
- F. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
- G. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum two duct widths from duct take-off.
- H. Use splitter dampers only where indicated.
- I. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

END OF SECTION 233300

**SECTION 233423
HVAC POWER VENTILATORS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Roof exhausters.
- B. Plastic centrifugal exhaust fans.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 233100 - HVAC Ducts and Casings.
- C. Section 233300 - Air Duct Accessories.
- D. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.
- E. Section 262923 - Variable-Frequency Motor Controllers.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate fan roof curbs and service utilities installation according to fan size.
- B. Sequencing: Ensure that utility connections are completed in an orderly and expeditious manner.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on fans and accessories, including fan curves with specified operating point plotted, power, rpm, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- C. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 ROOF EXHAUSTERS

- A. Manufacturers:
 - 1. Greenheck Fan Corporation: www.greenheck.com/#sle.
 - 2. Twin City Fan & Blower: www.tcf.com/#sle.
 - 3. Loren Cook Company: www.lorencook.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Fan Unit: V-belt or direct driven as indicated, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- C. Roof Curb: 18 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.

- D. Disconnect Switch: Factory wired, nonfusible, in housing for thermal overload protected motor and wall mounted multiple speed switch.
- E. Backdraft Damper: Aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- F. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm gets attained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.
- G. The submitted Fan Energy Index (FEI) shall meet or exceed the scheduled FEI.

2.02 PLASTIC CENTRIFUGAL EXHAUST FANS

- A. Manufacturers:
 - 1. Fantech, a Systemair Company: www.fantech.net/#sle.
 - 2. Substitutions: See Section 016000 - Product Requirements.
- B. Quality Assurance:
 - 1. HVI 916 certified
 - 2. Conforms to UL standard 507
 - 3. Conforms to CSA standard C22.2-113
 - 4. ENERGY STAR Certified
- C. Casing Construction:
 - 1. Constructed of plastic, resin material
 - 2. Inlet/outlet size:
 - a. 6-inch
- D. Motor Requirements:
 - 1. Alternating Current (AC), external-rotor motor.
 - 2. Single-phase motors:
 - a. 120V, permanent, split capacitor type.
 - 3. Permanently sealed, self-lubricating, ball-bearing type.
 - 4. Equipped with automatic reset thermal overload protection.
 - 5. Acceptable for continuous duty.
- E. Electrical:
 - 1. Completely enclosed, electrical wiring box with pre-wired terminal strip connections.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.
- D. Provide sheaves required for final air balance.
- E. Install backdraft dampers on inlet to roof and wall exhausters.

END OF SECTION 233423

**SECTION 233600
AIR TERMINAL UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single-duct, variable air volume units.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230548 - Vibration and Seismic Controls for HVAC.
- C. Section 230913 - Instrumentation and Control Devices for HVAC: Thermostats and actuators.
- D. Section 230923 - Direct-Digital Control System for HVAC.
- E. Section 230993 - Sequence of Operations for HVAC Controls.
- F. Section 232113 - Hydronic Piping: Connections to heating coils.
- G. Section 232114 - Hydronic Specialties: Connections to heating coils.
- H. Section 233100 - HVAC Ducts and Casings.
- I. Section 233300 - Air Duct Accessories.
- J. Section 233700 - Air Outlets and Inlets.
- K. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001, with Addenda (2011).
- B. AHRI 880 (I-P) - Performance Rating of Air Terminals; 2017 (Reaffirmed 2023).
- C. AHRI 885 - Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets; 2008, with Addendum (2011).
- D. ASHRAE RP-1455 - Seminar 65 - Standardized Best of Class Sequences for HVAC Systems; 2016.
- E. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2025.
- F. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. ASHRAE Std 130 - Laboratory Methods of Testing Air Terminal Units; 2025.
- H. ASTM A492 - Standard Specification for Stainless Steel Rope Wire; 1995 (Reapproved 2019).
- I. ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope; 2019.
- J. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2025.
- K. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2026a.
- L. ASTM E488/E488M - Standard Test Methods for Strength of Anchors in Concrete Elements; 2022.
- M. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.

- N. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- O. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- P. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems; 2024.
- Q. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.
- R. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate airflow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
 - 1. Include schedules listing discharge and radiated sound power level for each of the second through sixth-octave bands at inlet static pressures of 1 to 4 in-wc.
- D. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.
- E. Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.
- F. Project Record Documents: Record actual locations of units and locations of access doors required for access of valving.
- G. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.
- H. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements for additional provisions.
- J. **It is the responsibility of the Division 23 contractor to verify coil connection sides (left hand/right hand) prior to the approval and ordering of terminal equipment.**

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for air terminal units.

PART 2 PRODUCTS

2.01 SINGLE-DUCT, VARIABLE AIR VOLU UNITS

- A. Manufacturers:
 - 1. Price Industries, Inc: www.priceindustries.com/#sle.
 - 2. Titus HVAC: www.titus-hvac.com/#sle.
 - 3. Trane, a brand of Ingersoll Rand: www.trane.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Acoustic Performance Requirements:
 - 1. Use attenuation values found in appendix E of AHRI 885.
- C. General:
 - 1. Factory-assembled, AHRI 880 (I-P) rated and bearing the AHRI seal, air volume control terminal with damper assembly, flow sensor, externally mounted volume controller, duct collars, and all required features.
 - 2. Control box bearing identification, including but not necessarily limited to nominal cfm, maximum and minimum factory-set airflow limits, coil type and coil (right or left hand) connection, where applicable.
- D. Unit Casing:
 - 1. Minimum 22 gauge, 0.0299 inch galvanized steel.
 - 2. Air Inlet Collar: Provide round, suitable for standard flexible duct sizes.
 - 3. Unit Discharge: Rectangular, with slip-and-drive connections.
 - 4. Acceptable Liners:
 - a. Must comply with UL 181 and NFPA 90A.
 - b. 1/2 inch thick, coated, fibrous-glass complying with ASTM C1071.
 - 1) Secure with adhesive.
 - 2) Coat edges exposed to airstream with NFPA 90A approved sealant.
 - 3) Cover liner with non-porous foil.
 - c. 3/4 inch thick polyurethane foam adhesive complying with UL 181 erosion requirements in accordance with ASHRAE Std 62.1, and having a maximum smoke developed index of 50 for both insulation and adhesive, when tested in accordance with ASTM E84.
 - d. Liner not to contain pentabrominated diphenyl ether (CAS #32534-81-9) or octabrominated diphenyl ether.
- E. Damper Assembly:
 - 1. Heavy-gauge, galvanized steel, or extruded aluminum construction with solid steel, nickel-plated shaft pivoting on HDPE, self-lubricating bearings.
 - a. Nylon bearings are not acceptable.
 - b. Shaft shall be clearly marked on the end to indicate damper position.
 - 2. The damper shall incorporate a mechanical stop to prevent overstroking and a synthetic seal to limit close-off leakage.
 - 3. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.
 - 4. Incorporate low leak damper blades for tight airflow shutoff.
 - a. Air Leakage Past Closed Damper: Maximum two percent of unit maximum airflow at 3 in-wc inlet static pressure, tested in accordance with ASHRAE Std 130.
 - 5. Actuators shall be capable of supplying at least 35-inch lbs. of torque to the damper shaft and shall be mounted externally for service access.
- F. Hot Water Heating Coil:

1. Hot water reheat coils shall be enclosed in a minimum 20-gauge galvanized steel casing with slip and drive construction for attachment to metal ductwork.
 2. Coils shall be factory installed on the terminal discharge.
 3. Fins shall be rippled and corrugated heavy gauge aluminum, mechanically bonded to tubes.
 4. Tubes shall be copper with minimum wall thickness of 0.016-inch with male solder header connections.
 5. Coils shall be leak tested to 300 psi with minimum burst pressure of 1800 psi at ambient temperature.
 6. Number of coil rows and circuits shall be selected to provide performance as required per the plans.
 7. Coil performance data shall be based on tests run in accordance with AHRI Standard 410.
- G. Controls:
1. Terminal Unit Controls:
 - a. Provide accessories for field interfaced controller including ball valve and thermostat.
 - b. Sequence of Operation: Zone temperature control with airflow and coil discharge monitoring.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that conditions are suitable for installation.
- B. Verify that field measurements are as indicated on drawings.
- C. It is the responsibility of the division 23 contractor to verify coil connection sides (left hand/right hand) prior to the approval and ordering of terminal equipment.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.
- C. Provide ceiling access doors or locate units above easily removable ceiling components.
- D. Support units individually from structure with wire rope complying with ASTM A492 and ASTM A603 in accordance with SMACNA (SRM). See Section 23 0548.
- E. Do not support from ductwork.
- F. Connect to ductwork in accordance with Section 233100.
- G. Provide a minimum straight duct length at the inlet of each terminal unit equivalent to 5 times the inlet diameter size.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.

3.04 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals for closeout submittals.
- B. See Section 017900 - Demonstration and Training for additional requirements.

END OF SECTION 233600

**SECTION 233700
AIR OUTLETS AND INLETS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Square lay-in ceiling diffusers.
- B. Surface-mounted high capacity drum louvers.
- C. Duct-mounted supply and return grilles.
- D. Surface-Mounted exhaust and return registers/grilles.
- E. Ceiling lay-in egg crate exhaust and return grilles.
- F. Louvers.

1.02 RELATED REQUIREMENTS

- A. Section 265100 - Interior Lighting: Air handling light troffers.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Air Inlets; 2023.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.05 QUALITY ASSURANCE

- A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Price Industries: www.priceindustries.com/#sle
- B. Titus HVAC: www.titus-hvac.com/#sle.
- C. Krueger-HVAC: www.krueger-hvac.com/#sle.
- D. Substitutions: See Section 016000 - Product Requirements.

2.02 SQUARE LAY-IN CEILING DIFFUSERS

- A. Type: Provide square formed adjustable, backpan stamped, core removable, and multi-louvered ceiling diffusers constructed to maintain 360 degree discharge air pattern with sectorizing baffles where indicated.
- B. Connections: Round.
- C. Fabrication: Steel with baked enamel finish.
- D. Color: As selected by Architect from manufacturer's full range.

2.03 SURFACE-MOUNTED HIGH CAPACITY DRUM LOUVERS

- A. Type: Provide rectangular formed adjustable, core removable, surface-mounted drum louver.

- B. Construction:
 - 1. The outlets shall consist of individually adjustable spread control vanes housed within a rotatable drum.
 - 2. The drum pivot mechanism shall incorporate a positive positioning detent device to hold field adjusted drum angles of up to thirty degrees off-center. Adjustable vanes shall pivot and maintain blade setting.
 - 3. The outlet mounting frame shall be constructed of formed steel with welded, reinforced corners for added strength.
 - 4. The mounting frame shall be supplied with countersunk screw holes for aesthetic appeal.
- C. Connections: Rectangular.
- D. Fabrication: Steel with baked enamel finish.
- E. Color: As selected by Architect from manufacturer's full range.
- F. Accessories:
 - 1. Opposed Blade Damper:
 - a. The heavy duty, opposed blade balancing damper shall be constructed of a minimum 18 gauge coated, cold rolled steel. The damper frame corners shall overlap and be of welded construction for added strength.
 - b. The damper shall be operable from the register face.
 - c. The damper shall be supplied fitted with a face accessible screw-type blade locking mechanism.

2.04 DUCT-MOUNTED SUPPLY AND RETURN GRILLES

- A. Type: Duct-mounted, rectangular grille for round-spiral duct with adjustable pivot-ended blades, end caps, and dual cover flanges to lay flush on duct surface regardless of diameter. Performance to match manufacturer's catalog data.
- B. General Spaces:
 - 1. Material: 22 gauge steel.
 - 2. Thickness: 0.0299 inch (0.76 mm).
 - 3. {CH#295947}
- C. Pool Applications:
 - 1. Material: 22 gauge stainless steel.
 - 2. Thickness: 0.0299 inch (0.76 mm).
 - 3. Provide with rectangular tap fitting.
- D. Color: As selected by Architect from manufacturer's full range.

2.05 SURFACE-MOUNTED EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting.
- C. Fabrication: Steel with 20 gauge, 0.0359 inch minimum frames and 22 gauge, 0.0299 inch minimum blades, steel and aluminum with 20 gauge, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.
- D. Color: To be selected by Architect from manufacturer's full range.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face where not individually connected to exhaust fans.

2.06 CEILING LAY-IN EGG CRATE EXHAUST AND RETURN GRILLES

- A. Type: Egg crate style face consisting of 1/2 by 1/2 by 1/2 inch grid core.
- B. Fabrication: Grid core consists of aluminum with mill aluminum finish.
- C. Color: To be selected by Architect from manufacturer's full range.
- D. Frame: Channel lay-in frame for suspended grid ceilings.
- E. Accessories: Provide 45 degree angled eggcrate or other similar provisions for visual blocking such as angled louver or 90 degree duct elbow.

2.07 LOUVERS

- A. Manufacturers:
 - 1. Greenheck: www.greenheck.com/#sle.
 - 2. NCA, a brand of Metal Industries Inc: www.ncamfg.com/#sle.
 - 3. Ruskin Company: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Type: 6 inch deep frame with blades on 45 degree slope with center baffle and return bend, heavy channel frame, 1/2 inch square mesh screen over intake or exhaust end.
- C. Fabrication: 16 gauge, 0.0598 inch (1.52 mm) thick galvanized steel thick galvanized steel welded assembly, with factory prime coat finish.
- D. Color: To be selected by Architect from manufacturer's full range.
- E. Mounting: Furnish with interior flat flange for installation.
- F. Accessories:
 - 1. Louvers shall be the drainable type.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.
- C. Install diffusers to ductwork with air tight connection.
- D. Provide balancing dampers on duct take-off to diffusers and grilles and registers, despite whether dampers are specified as part of diffuser, or grille and register assembly.
- E. Paint ductwork visible behind air outlets and inlets matte black, see Section 099123.
- F. Louver plenum boxes shall include a drain at the low point of the box.

3.02 CLOSEOUT ACTIVITIES

- A. Demonstrate operational system to Owner's representative.
- B. Instruct Owner's representative to maintain system and use occupant controls or interfaces, as required.

3.03 PROTECTION

- A. Protect installed products until completion of project.
- B. Replace, repair, or touch-up damaged products before Substantial Completion.

END OF SECTION 233700

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SECTION 236213

PACKAGED AIR-COOLED REFRIGERANT COMPRESSOR AND CONDENSER UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Condensing unit package.
- B. Charge of refrigerant and oil.
- C. Controls and control connections.
- D. Refrigerant piping connections.
- E. Motor starters.
- F. Electrical power connections.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230993 - Sequence of Operations for HVAC Controls.
- C. Section 232300 - Refrigerant Piping.
- D. Section 237313 - Modular Indoor Central-Station Air-Handling Units.
- E. Section 238200 - Convection Heating and Cooling Units: Air Coils.

1.03 REFERENCE STANDARDS

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2026.
- B. AHRI 365 (I-P) - Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units; 2009.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2024, with Addendum (2026).
- D. ASHRAE Std 23 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Compressor Units; 2022.
- E. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- G. NEMA MG 00001 - Motors and Generators; 2024.
- H. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams. To ensure capacities are complementary, include equipment served by condensing units in submittal or submit at the same time.
- C. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Include schematic layouts showing

condensing units, cooling coils, refrigerant piping, and accessories required for complete system.

- D. Operation and Maintenance Data: Include start-up instructions, maintenance instructions, parts lists, controls, and accessories.
- E. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

- A. Unit shall be certified in accordance with UL Standard 60335-2-40 and CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
- B. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
- C. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed. Unit nameplate shall include the ETL label.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Unit shall be shipped on a wooden pallet with skeleton crating prior to shipment with doors bolted shut to prevent damage during transport and thereafter while in storage awaiting installation.
- C. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
- D. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation and Maintenance manual.
- E. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
- F. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.

1.07 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide a five year warranty to include coverage for refrigerant compressors.
- C. Manufacturer shall provide a limited "parts only" warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer's written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance and refrigerant.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Aeon: www.aeon.com/#sle.
- B. Samsung: <https://www.samsunghvac.com/#sle>.
- C. York, a brand of Johnson Controls International, PLC: www.york.com/#sle.
- D. Substitutions: See Section 016000 - Product Requirements.

2.02 MANUFACTURED UNITS

- A. Units: Self-contained, packaged, factory assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressors, condensing coil and fans, integral sub-cooling coil, controls, liquid receiver, wind deflector, and screens.
 - 1. Unit shall be factory assembled and tested including leak testing of the coil and run testing of the completed unit. Run test report shall be supplied with the unit in the control compartment.
- B. Construction and Ratings: In accordance with AHRI 210/240. Test in accordance with ASHRAE Std 23.
 - 1. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.
- C. Performance Ratings: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE Std 90.1.
- D. Refrigerant: Unit shall be designed for use with R-454B refrigerant.

2.03 CASING

- A. Unit shall be completely factory assembled, piped, and wired and shipped in one section.
- B. All cabinet walls, access doors, and roof shall be fabricated of G90 galvanized steel panels.
- C. Unit shall be specifically designed for outdoor application.
- D. Access to compressors and control components shall be through hinged access doors with quarter turn, lockable handles.
- E. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
- F. Unit shall include forklift slots.
- G. Mount starters, disconnects, and controls in weatherproof panel provided with full opening access doors. Provide mechanical interlock to disconnect power when door is opened.
- H. Provide removable access doors or panels with quick fasteners and piano hinges.

2.04 CONDENSER COILS

- A. Coils shall be designed for use with R-454B refrigerant. Coils shall be multi-pass and fabricated from aluminum microchannel tubes.
- B. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.
- C. Coils shall be hydrogen leak tested.

2.05 FAN REQUIREMENTS

- A. Condenser fans shall be horizontal discharge, axial flow, direct drive fans.
- B. Condensing unit shall be provided with an electrically commutated motor (ECM) condenser fan, condenser head pressure controller, and discharge pressure transducers for modulating head

pressure control to allow cooling operation down to 35°F. Fan motor shall be weather protected, single phase, direct drive, and totally enclosed air over (TEAO) with electronic protection.

- C. Motors as indicated, in compliance with Section 230513.

2.06 COMPRESSORS

- A. Unit shall be provided with one independently circuited R-454B variable capacity scroll compressor with thermal overload protection. Variable capacity scroll compressor shall be capable of modulation from 10-100% of its capacity.
- B. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged access doors shall provide access to the compressors.
- C. Shall be equipped with a 5 minute off delay timer to prevent compressor short cycling.
- D. Condensing unit shall be provided with adjustable compressor lockout.
- E. Mounting: Statically and dynamically balance rotating parts and mount on spring vibration isolators.
- F. Lubrication System: Reversible, positive displacement oil pump with oil charging valve, oil level sight glass, and magnetic plug or strainer.
- G. Motor: Constant speed 1800 rpm suction gas cooled with electronic sensor and winding over temperature protection, designed for across-the-line starting.
 - 1. Furnish with starter, see Section 230513.
- H. Capacity Reduction Equipment: Suction valve unloaders, with lifting mechanism operated by electrically actuated solenoid valve, with unloaded compressor start; controlled from suction pressure.
- I. Sump Oil Heater: Evaporates refrigerant returning to sump during shut down. Energizes heater continuously when compressor is not operating.

2.07 REFRIGERANT CIRCUIT

- A. Provide each unit with one refrigerant circuit, factory-supplied and piped. See Section 232300.
- B. Unit shall include a factory holding charge of R-454B refrigerant and oil. Adjusting the charge of the system will be required during installation.
- C. For each refrigerant circuit, provide:
 - 1. Filter dryer replaceable core type.
 - 2. Liquid line sight glass and moisture indicator.
 - 3. Thermal expansion valve for maximum operating pressure.
 - 4. Insulated suction line.
 - 5. Suction and liquid line service valves and gauge ports.
 - 6. Liquid line solenoid valve.
 - 7. Charging valve.
 - 8. Discharge line check valve.
 - 9. Compressor discharge service valve.
 - 10. Condenser pressure relief valve.
- D. For heat pump units, provide reversing valve, suction line accumulator, flow control check valve, and solid-state defrost control utilizing thermistors.

2.08 ELECTRICAL

- A. Unit shall be provided with standard power block for connecting power to the unit.
- B. Control circuit transformer and wiring shall provide 24 VAC control voltage from the line voltage provided to the unit.
- C. Unit shall have a 5kAIC SCCR.
- D. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
- E. Unit shall be provided with factory installed and factory wired 115V, 12 amp GFI outlet in the unit control panel.
- F. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more than 10% under design voltage, or on phase reversal.
- G. Unit shall be provided with remote stop/start terminals which require contact closure for unit operation. When these contacts are open the low voltage circuit is broken and the unit will not operate.
- H. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.

2.09 CONTROLS

- A. Unit shall be provided with a terminal block for field installation of controls. Option shall include factory installed isolation relays.
- B. On unit, mount weatherproof steel control panel, NEMA EN 10250, containing power and control wiring, molded case disconnect switch, factory wired with single point power connection.
- C. For each compressor, provide across-the-line starter, nonrecycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection. For each condenser fan, provide across-the-line starter with starter relay.
- D. Provide safety controls arranged so any one will shut down machine:
 - 1. High discharge pressure switch (manual reset) for each compressor.
 - 2. Low suction pressure switch (automatic reset) for each compressor.
 - 3. Oil Pressure switch (manual reset).
- E. Provide controls to permit operation down to 0 degrees F ambient temperature.
 - 1. Thermostat to cycle fan motors in response to outdoor ambient temperature.
 - 2. Head pressure switch to cycle fan motors in response to refrigerant condensing pressure.
 - 3. Solid state control to vary speed of one condenser fan motor in response to refrigerant condensing pressure.
 - 4. Electronic control consisting of mixing damper assembly, controlled to maintain constant refrigerant condensing pressure.
- F. Gauges: Piped for suction and discharge refrigerant pressures and oil pressure for each compressor.
- G. Provide electric solid state microcomputer based room thermostat, located as indicated.
 - 1. Incorporate:
 - a. Automatic switching from heating to cooling.
 - b. Preferential rate control to minimize overshoot and deviation from set point.

- c. Set-up for four separate temperatures per day.
 - d. Instant override of setpoint for continuous or timed period from one hour to 31 days.
 - e. Short cycle protection.
 - f. Programming based on weekdays, Saturday and Sunday.
 - g. Switch selection features including imperial or metric display, 12 or 24 hour clock, keyboard disable, remote sensor, fan on-auto.
- 2. Display shall include:
 - a. Time of day.
 - b. Programmed temperature.
 - c. Programmed time.
 - d. Duration of timed override.
 - e. Day of week.
 - f. System Mode Indication: Heating, cooling, auto, off, fan auto, fan on.
 - g. Stage (heating or cooling) operation.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's installation instructions.
 - 1. Installation, Operation and Maintenance manual shall be supplied within the unit.
- B. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions.
- C. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.

3.02 SYSTEM STARTUP

- A. Supply initial charge of refrigerant and oil for each refrigeration system. Replace losses of oil or refrigerant prior to end of correction period.
- B. Charge system with refrigerant and test entire system for leaks after completion of installation. Repair leaks, put system into operation, and test equipment performance.
- C. Shut-down system if initial start-up and testing takes place in winter and machines are to remain inoperative. Repeat start-up and testing operation at beginning of first cooling season.
- D. Provide cooling season start-up, and winter season shut down for first year of operation.

END OF SECTION 236213

SECTION 237313
MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Casing construction.
- B. Fan section.
- C. Coil section.
- D. Filter and air cleaner section.
- E. Mixing Box & Damper section.
- F. Total energy recovery wheel section.
- G. Controls.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230593 - Testing, Adjusting, and Balancing for HVAC.
- C. Section 230719 - HVAC Piping Insulation.
- D. Section 233300 - Air Duct Accessories: Flexible duct connections.
- E. Section 236213-Packaged Air-Cooled Refrigerant Compressor and Condenser Units.
- F. Section 251500 - Integrated Automation Software.

1.03 REFERENCE STANDARDS

- A. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001, with Addenda (2011).
- B. AHRI 1060 (I-P) - Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment; 2023.
- C. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2025.
- E. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2018.
- F. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. ASTM B177/B177M - Standard Guide for Engineering Chromium Electroplating; 2011 (Reapproved 2017).
- H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL (DIR) - Online Certifications Directory; Current Edition.
- J. UL 1812 - Ducted Heat Recovery Ventilators; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate the installation of _____ with size, location and installation of service utilities.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data:
 - 1. Published Literature: Indicate dimensions, weights, capacities, ratings, gauges and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
 - 3. Fans: Performance and fan curves with specified operating point clearly plotted, power, RPM.
 - 4. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
 - 5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- C. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- D. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- E. Manufacturer's Instructions: Include installation instructions.
- F. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements for additional provisions.
 - 2. Extra Filters: Two sets for each unit.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Unit shall be certified in accordance with UL Standard 1995 (UL 60335-2-40)/ CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
- C. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
- D. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed.
- E. Unit Seasonal Energy Efficiency Ratio (SEER) shall be equal to or greater that prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings. [2-5 ton]

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

- B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- C. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
- D. Unit shall be on a wooden pallet with skeleton crating prior to shipment to prevent damage during transport and thereafter while in storage awaiting installation.
- E. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.
- F. Unit shall be handled carefully to avoid damage to components, enclosures and finish.
- G. Unit shall be stored in a clean, dry place protected from weather and construction traffic in accordance with Installation, Operation and Maintenance manual instructions.
- H. Unit shall be shipped in sections and tested including leak testing of the coils and run testing of the supply fans and factory wired electrical system. Run test report shall be supplied with the unit in the control compartment's literature packet, and also available electronically after the unit ships. Assembled in field by contractor.
- I. Unit shall have decals and tags to indicate lifting and rigging, service areas, and caution areas for safety and to assist service personnel.
- J. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.

1.08 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer shall provide a limited "parts only" warranty for a period of 12 months from the date of equipment start up or 18 months from the date of original equipment shipment from the factory, whichever is less.
- C. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer's written instructions for installation, operation, and maintenance have been followed.

PART 2 PRODUCTS**2.01 MANUFACTURERS**

- A. AAON; www.aaon.com/#sle.
- B. Carrier Global Corporation: www.carrier.com/#sle.
- C. York, a brand of Johnson Controls International, PLC: www.york.com/#sle.
- D. Substitutions: See Section 016000 - Product Requirements.

2.02 REGULATORY REQUIREMENTS

- A. Comply with NFPA 70.
- B. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

2.03 UNIT DESCRIPTION

- A. Indoor air handling units shall include filters, supply fan, DX evaporator coil, hot gas reheat coil, hot water coil, mixing box, exhaust fan, energy recovery wheel, and a low voltage terminal block for field installed controls.

2.04 CASING CONSTRUCTION

- A. Full Perimeter Base Rail:
 - 1. Construct of galvanized steel.
 - 2. Provide base rail of sufficient height to raise unit for external trapping of condensate drain pans.
- B. Casing:
 - 1. All cabinet walls and access doors shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
 - 2. Unit insulation shall have a minimum thermal resistance R-value of 6.25. Foam insulation shall have a density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929-11 for a minimum flash ignition temperature of 610°F.
 - 3. Provide mid-span, no through metal, internal thermal break.
 - 4. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel and prevents exterior condensation on the panel.
 - 5. Casing Air Pressure Performance Requirements:
 - a. Able to withstand up to 8 in-wc positive or negative static pressure.
 - b. Not to exceed 0.0042 inches per inch deflection at 1.5 times design static pressure up to a maximum of plus 8 in-wc in positive pressure sections and minus 8 in-wc in negative pressure sections.
- C. Access Doors:
 - 1. Construction, thermal and air pressure performance same as casing.
 - 2. Provide unit with hinged access doors with lockable handles.
 - 3. All access doors shall be flush mounted to cabinetry.
- D. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities.
- E. Casing Leakage: Seal joints and provide airtight access doors so that air leakage does not exceed one percent of design flow at the specified casing pressure.
- F. Drain Pan Construction:
 - 1. Units shall include double-sloped 304 stainless steel drain pan.
 - 2. Drain pans shall comply with ASHRAE Std 62.1 for indoor air quality and sufficiently sized to collect all condensate.
 - 3. Locate outlet of sufficient diameter at lowest point of pan to prevent overflow at normal operating conditions.
 - 4. Provide threaded drain connections constructed of drain pan material, extended sufficient distance beyond the base to accommodate field installed, condensate drain trapping.
- G. Louvers: Refer to section 233700 "Air Outlets and Inlets".
- H. Finish:
 - 1. Indoor Units:

- a. Provide exterior, galvanized steel panels with painted surface complying with ASTM B177/B177M.
 - b. Color: Manufacturer's standard color.
- I. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.

2.05 FAN SECTION

- A. Supply Fans:
 - 1. Unit shall include direct drive, unhusd, backward curved, plenum supply fans.
 - 2. Blower and motor assembly shall be dynamically balanced.
 - 3. Motor shall be IE5 efficiency permanent magnet totally enclosed motor. Variable frequency drive (VFD) shall be factory wired and mounted in the unit.
 - 4. Blower and motor assembly shall utilize neoprene gasket.
- B. Exhaust Fans:
 - 1. Unit shall include direct drive, unhusd, backward curved, plenum exhaust fans.
 - 2. Blower and motor assembly shall be dynamically balanced.
 - 3. Motor shall be a high efficiency electronically commutated motor (ECM).
 - 4. Blower and motor assembly shall utilize neoprene gasket.
 - 5. Access to exhaust fan shall be through an access door with removable pin hinges and lockable quarter turn handles.
 - 6. ECM driven exhaust fan shall include a factory installed potentiometer within the control compartment for cfm setpoint. The factory provided terminal block shall include a jumper wire that can be removed when wired to field provided 0-10 VDC control signal.
- C. Performance Ratings: Determined in accordance with AMCA 210 and labeled with AMCA Certified Rating Seal.
- D. Bearings: Self-aligning, grease lubricated, with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.

2.06 COIL SECTION

- A. Coil access shall be through service access door with piano hinges and lockable quarter turn handle.
- B. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.
- C. Drain Pans: 24 inch downstream of coil and down spouts for cooling coil banks more than one coil high.
- D. Eliminators: Three break of galvanized steel, mounted over drain pan.
- E. Air Coils:
 - 1. Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.
 - 2. Coil shall be hydrogen leak tested.
- F. Fabrication:
 - 1. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
 - 2. Fins: Aluminum.
 - 3. Casing: Die formed channel frame of galvanized steel.

G. Water Heating Coils:

1. Coil shall be designed and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
2. Coils shall be located in the preheat position upstream of the cooling coil.
3. Supply and return connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.
4. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.
5. Coil shall be certified in accordance with AHRI Standard 410 and be hydrogen leak tested.
6. Coil access shall be through service access door with piano hinges and lockable quarter turn handle. Control valves shall be field supplied and field installed.
7. Control valves shall be field supplied and field installed.

H. Refrigerant Coils:

1. Coil shall be designed for use with R-454B refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
2. Air handling unit and matching condensing unit shall be capable of operation as an R-454B split system heat pump.
3. Access to cooling coil shall be through hinged access door with lockable quarter turn handles.
4. Coil shall be furnished with factory installed thermostatic expansion valves. The sensing bulbs shall be field installed on the suction line immediately outside the cabinet.
5. Liquid and suction connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.
6. Cooling coil shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.

I. Hot Gas Reheat Coils:

1. Modulating hot gas reheat shall be provided on the lead refrigeration circuit. Air handling unit shall be provided with hot gas reheat coil.
2. Access to reheat coil shall be through hinged access door with lockable quarter turn handles.
3. Modulating hot gas reheat shall be provided on the refrigeration circuit. Air handling unit shall be provided with hot gas reheat coil, a check valve on the liquid line, and a check valve on the hot gas reheat line. The matching condensing unit must include modulating 3-way reheat valve, liquid line receiver, electronic controller, supply air temperature sensor and a dehumidification control signal terminal.
4. Reheat line connections shall be labeled, extend beyond the unit casing and be located near the suction and liquid line connections for ease of field connection. Connections shall be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.

2.07 FILTER SECTION

- A. General: Provide filter sections with filter racks, minimum of one access door for filter removal, and filter block-offs to prevent air bypass.

- B. Unit shall include 4 inch thick, pleated panel filters with a MERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with MERV rating of 8, upstream of the 4 inch standard filters.
- C. Unit filter access shall be through service access door with piano hinges and draw latches.
- D. Differential Pressure Gauge:
 - 1. Provide factory installed dial type differential pressure gauge, flush mounted with casing outer wall, and fully piped to both sides of each filter to indicate status.
 - 2. Maintain plus/minus 5 percent accuracy within operating limits of 20 degrees F to 120 degrees F.

2.08 MIXING BOX AND DAMPER SECTION

- A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor, return, and exhaust air.
- B. Damper Blades:
 - 1. Double-skin airfoil design with metal, compressible jamb seals and extruded-vinyl blade-edge seals on each blade.
 - 2. Self-lubricating stainless steel or synthetic sleeve bearings.
 - 3. Comply with ASHRAE Std 90.1 I-P for rated maximum leakage rate.
 - 4. Provide leakage testing and pressure ratings in compliance with AMCA 500-D test methods.
 - 5. Arrange in parallel or opposed-blade configuration.
 - 6. Dampers shall be controlled by a fully modulating actuator.

2.09 TOTAL ENERGY RECOVERY WHEEL SECTION

- A. Unit shall contain an energy recovery cabinet with back outside air opening, back exhaust air opening, top return air opening, and top supply air opening.
- B. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings.
- C. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals.
- D. Certified in accordance with AHRI 1060 (I-P) and UL 1812 for mechanical, electrical, and fire safety.
- E. Wheel Construction:
 - 1. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
 - 2. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.
 - 3. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be

continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

4. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The energy transfer media shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
 5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
 6. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.
- F. Maintenance and Access Features:
1. Access doors upstream and downstream of the wheel cassette.
 2. Wheel frame shall slide out for service and removal from the cabinet.
 3. Energy recovery wheel access shall be through service access door with piano hinges and quarter turn button fasteners.
 4. Adequate space for cleaning, service, and maintenance.
- G. Controls:
1. Wheel Control: Damper control of recovery capacity to 40 percent of initial total recovery capacity.
 2. Unit shall include energy recovery wheel defrost control to periodically stop the wheel rotation, which allows the warm exhaust air to defrost the wheel. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.
 3. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.

2.10 ELECTRICAL

- A. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
- B. Unit shall have a 5kAIC (10kAIC) SCCR.
- C. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more than 10% under design voltage or on phase reversal.
- D. Unit shall be provided with remote safety shutdown terminals for wiring to a field installed smoke detector, firestat, or building safety automatic shutdown system.
- E. Unit shall include high and low voltage quick connects for easy wiring at installation.

2.11 CONTROLS

- A. Field Installed DDC Controls by Others:
 - 1. Factory Installed and Factory Provided Controller shall not be provided. Equipment shall be provided with individual controls for components listed above to have factory control devices (i.e. refrigeration system, Energy Recovery, etc.). Unit shall be provided with a terminal block and a supply air setpoint potentiometer.
- B. Unit shall be provided with a proof of airflow switch. When airflow is not detected, other electrical components cannot power on.
- C. Unit shall be provided with an external control panel with separate low voltage control wiring with conduit and high voltage power wiring with conduit between the control panel and the unit. Control panel shall be field mounted.
- D. Access to external control panel shall be through hinged access door with tooled entry.
- E. Unit shall include a high water level switch in the drain pan.
- F. Unit shall include a clogged filter switch that senses the pressure drop across the unit filter bank and cooling coil.
- G. Unit shall include factory installed magnehelic gauge measuring the pressure drop across the filter rack and cooling coil.
- H. Unit shall include a clogged filter switch that senses pressure drop across the outside air filters and energy recovery wheel.
- I. Unit shall be provided with a proof of airflow switch. When airflow is not detected, the supply fans will shut down.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.
- C. Bolt sections together with gaskets.
- D. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
- E. Provide fixed sheaves required for final air balance.
- F. Make connections to coils with unions or flanges.
- G. Hydronic Coils:
 - 1. Hydronic Coils: Connect water supply to leaving air side of coil (counterflow arrangement).
 - 2. Provide shut-off valve on supply line and lockshield balancing valve with memory stop on return line.
 - 3. Locate water supply at bottom of supply header and return water connection at top.
 - 4. Provide manual air vents at high points complete with stop valve.
 - 5. Ensure water coils are drainable and provide drain connection at low points.
- H. Refrigerant Coils: Provide sight glass in liquid line within 12 inches of coil.
- I. Cooling Coils:
 - 1. Pipe drain and overflow to nearest floor drain.

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.

3.03 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform systems startup.
- B. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations.
- C. Adjust for proper operation within manufacturer's published tolerances.

3.04 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals for closeout submittals.
- B. See Section 017900 - Demonstration and Training for additional requirements.
- C. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.

END OF SECTION 237313

**SECTION 237314
POOL DEHUMIDIFICATION UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Casing construction.
- B. Fan section.
- C. Coil section.
- D. Filter and air cleaner section.
- E. Mixing Box & Damper section.
- F. Total energy recovery wheel section.
- G. Remote air-cooled condenser section.
- H. Electrical.
- I. Controls.
- J. Sensors.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230593 - Testing, Adjusting, and Balancing for HVAC.
- C. Section 230719 - HVAC Piping Insulation.
- D. Section 233100 - HVAC Ducts and Casings
- E. Section 233300 - Air Duct Accessories: Flexible duct connections.

1.03 REFERENCE STANDARDS

- A. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001, with Addenda (2011).
- B. AHRI 1060 (I-P) - Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment; 2023.
- C. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2025.
- D. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2018.
- E. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. ASTM B177/B177M - Standard Guide for Engineering Chromium Electroplating; 2011 (Reapproved 2017).
- G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL (DIR) - Online Certifications Directory; Current Edition.
- I. UL 1812 - Ducted Heat Recovery Ventilators; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing of Construction:

1. Ensure that utility connections are achieved in an orderly and expeditious manner.
2. Ensure that products of this section are supplied to affected trades in time to prevent interruption of construction progress.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data:
 1. Published Literature: Indicate dimensions, weights, capacities, ratings, gauges and finishes of materials, and electrical characteristics and connection requirements.
 2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
 3. Fans: Performance and fan curves with specified operating point clearly plotted, power, RPM.
 4. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
 5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- C. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- D. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- E. Manufacturer's Instructions: Include installation instructions.
- F. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 016000 - Product Requirements for additional provisions.
 2. Extra Filters: Two sets for each unit.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Minimum 5-year experience manufacturing similar products.
- B. Unit shall be certified in accordance with UL Standard 1995 (UL 60335-2-40)/ CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
- C. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
- D. Member in good standing in the Air Conditioning, Heating, and Refrigeration Institute (AHRI)

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Handle materials as recommended by the manufacturer to avoid damage.
- B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- C. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
- D. Follow Installation, Operation and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

1.08 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.

- B. The manufacturer shall warrant all components (except as noted) for a period of two (2) years from the date of shipment. This warranty shall be limited to the supply of new or rebuilt parts, at the discretion of the manufacturer, for the part which has failed because of defects in workmanship or material, and does not include the cost for labor, transportation or other costs not herein provided for. Replaced parts are warranted only for the remaining portion of the original warranty period.
- C. Compressor Three (5)-Year Extended Warranty: This warranty shall be limited to the supply of new or rebuilt parts for the part which has failed because of defects in workmanship or material, and does not include the cost of labor, transportation or other costs not herein provided for. Replaced parts are warranted only for the remaining portion of the original warranty period.
- D. The manufacturer shall provide a (5)-year air side coil warranty.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Desert Aire: www.desert-aire.com/#sle.
- B. Air Enterprise: www.airenterprises.com/#sle.
- C. Efficient Air Systems, Inc: www.efficientairsys.com/#sle.
- D. Substitutions: See Section 016000 - Product Requirements.
 - 1. The Division 23 Contractor shall be responsible for any additional cost associated with an accepted substitution.

2.02 REGULATORY REQUIREMENTS

- A. Comply with NFPA 70.
- B. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

2.03 UNIT DESCRIPTION

- A. Indoor air handling units shall include filters, supply fan, DX evaporator coil, hot gas reheat coil, hot water coil, pool water heat exchanger, mixing box, exhaust fan, energy recovery wheel, and factory provided controls.

2.04 CASING CONSTRUCTION

- A. Full Perimeter Base Rail:
 - 1. Base rails and supports constructed of 12-gauge Galvanneal steel channels.
 - 2. Provide base rail of sufficient height to raise unit for external trapping of condensate drain pans.
- B. Casing:
 - 1. Exterior cabinet panels made of 16-gauge Galvanneal steel with powder coat paint.
 - 2. Panels will be lined with thermal and sound insulation made of engineered polymer cell foam (EPFI) 0.375 inches thick on indoor units.
 - 3. Sectional Cabinet: The dehumidifier shall be manufactured in sections for ease of installation at the jobsite.
 - a. Section weights shall be provided.
 - b. The factory shall perform a full functional test as a complete assembly before shipping.
 - c. Refrigeration valves shall be provided when sectioning of refrigeration circuits is required.

- d. Split wiring harnesses with mating connectors and terminal strips shall be provided to ease the re-assembly process.
 - e. Each cabinet section shall be manufactured with flanged edges and gaskets for sealing sections.
 - f. The manufacturer shall supply detailed drawings after purchase order. These "as built" drawing shall include dimensions, weights, wiring harness detail, refrigeration valve details, wiring diagrams, and points list.
 - g. The manufacturer shall provide a set of detailed assembly instructions.
 - h. A Factory Assisted start-up is required to verify assembly and installation before a unit's refrigeration system is energized.
- C. Access Doors:
 - 1. Removable panels with insert nut screw sites shall be provided to allow easy access to all internal parts and components.
- D. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities.
- E. Drain Pan Construction:
 - 1. All drain pans shall be a minimum 20-gauge stainless steel.
 - 2. Drain pans will be sloped and positioned under each evaporator coil.
 - 3. Each evaporator coil shall have a separate condensate drain pan.
 - 4. Drain pans shall comply with ASHRAE Std 62.1 for indoor air quality and sufficiently sized to collect all condensate.
 - 5. Locate outlet of sufficient diameter at lowest point of pan to prevent overflow at normal operating conditions.
 - 6. The drain pan will be fitted with a 1.5 inch MPT (Male Pipe Thread) non-corrosive plastic drain pipe extending from the dehumidifier to be connected to by the contractor.
- F. Louvers: Refer to section 233700 "Air Outlets and Inlets".
- G. Finish:
 - 1. Indoor Units:
 - a. Prior to painting, all metal parts shall be pretreated to remove oils and dirt and rinsed with an ionized solution.
 - b. Painting shall be by a powder coat technique to assure positive adherence with a high impact finish. All sides of panels shall be painted after manufacturing. The paint shall be High Yield Polyester. The paint shall be rated to meet a minimum of 1,000-hour salt spray test (ASTM B117), have a minimum Direct Impact Resistance of 160 in-lbs (ASTM D2794), have a minimum flexibility of ¼" Mandrel (ASTM D522, Method B) and a minimum 1000-hour Humidity Resistance (ASTM D2247).
 - c. Color: Manufacturer's standard color.

2.05 FAN SECTION

- A. Supply Fans:
 - 1. The dehumidifier shall have a single supply fan.
 - 2. The supply fan shall be driven by an AC motor.
 - a. Fan Type:
 - 1) Double inlet forward curve fan
 - 2) Galvanized steel impeller and housing.
 - 3) Pillow block bearings with grease fittings.
 - 3. Assembly:

- a. The shaft bearings shall be self-aligning, deep groove ball type, in pillow blocks housings.
 - b. All bearings are selected for a minimum of a L50 Lifetime of 100,000 hours.
 - c. The blower assembly shall be statically and dynamically balanced.
 - d. The motor sheave will be a variable pitch type to allow for field adjustment of air flow and external static.
- B. Exhaust Fans:
 1. The dehumidifier shall have a single or two plenum exhaust fans arranged in a fan array.
 2. Each fan in the fan array shall be driven by a direct-drive electronically commutated (EC) motor.
 3. To ensure that correct flow rates are maintained, all exhaust fans automatically modulate.
 4. Assembly:
 - a. Single-sided intake, rear-curved motor impeller, energy-optimized for operation without spiral housing through special blade design with rotating, vaneless diffuser for high efficiency.
 - b. Inlet nozzle with volume flow rate measuring equipment.
 - c. Shafts are designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
 - d. Designed to operate at no more than 70 percent of the first critical speed at top of the fan's speed range.
 - e. The complete blower assembly shall be statically and dynamically balanced.

2.06 COIL SECTION

- A. General Refrigerant Coils:
 1. Construction:
 - a. Coils shall be fabricated from seamless drawn copper. The tubes shall be hydraulically expanded into the aluminum fins to form a permanent metal-to-metal bond for maximum heat transfer and stability.
 - b. The fin surface on the refrigerant coils shall be continuous plate type aluminum
 - c. All air-side refrigeration shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance on the complete coil assembly including casing, distributor tubes and header. Heat transfer coefficient loss shall be less than 1% after coating. Minimum salt spray resistance per ASTM B117-97 / DIN 53167 after coating shall be 15,000 hours. Phenolic coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.
- B. Pool Water Heating:
 1. In addition to a remote air-cooled condenser, each refrigerant circuit in the unit will also have a pool water heat exchanger.
 2. Pool water heat exchangers will be tube-in-tube coaxial condensers.
 3. The dehumidifier's circuit "A" shall be equipped with a water condenser that rejects heat to the pool water loop. (Note: Since circuit "A" provides more recovered energy than circuit "B" it should be the first choice for pool or spa water heating).
 4. The dehumidifier's circuit "B" shall be equipped with a water condenser that rejects heat to the pool or spa water loop.
 5. The water side of the condenser shall be rated for 150 PSI (1034.2 kPA) operating fluid pressure.

6. The condenser(s) shall be sized for the total heat of rejection (THR) of the circuit to which it is connected.
 7. The entering water temperature range shall be between 36°F (2.2°C) and 104°F (40.0°C).
 8. The dehumidifier shall be equipped with one water flow switch per pool or spa water condenser. A water flow switch shall prevent compressor operation in the event of loss of water flow and a call for sensible cooling.
 9. A water temperature sensor and well shall be provided for each pool or spa water loop. The sensor(s) shall be installed by the mechanical contractor in the main water loop upstream of the pool heater and dehumidifier, constant water flow required across the sensor.
 10. Control valves and/or pumps for the pool or spa water condenser(s) are contractor provided and field installed.
- C. Heating Hot Water Coil:
1. The hot water coil capacity shall be in accordance with the dehumidifier schedule.
 2. The hot water coil shall be internal and an integral to the unit.
 3. The hot water coil shall be rated for 250 PSI (1723.7 kPa) operating pressure.
 4. The hot water coil shall be leak tested at the factory.
 5. The hot water coil shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance on the complete coil assembly including casing, distributor tubes and header. Phenolic coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.
 6. Freeze protection
 - a. The system will include an array of three temperature sensors.
 - b. When any sensor reads a temperature of 35°F (1.7°C) or below, the unit will de-energize the blower(s), close the outdoor air damper and force the heat output to maximum.
 - c. The unit will go into alarm mode and will need to be manually reset to restart the unit.
- D. Cooling Coils:
1. Coil shall be designed for use with R-454B refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
 2. The coil shall be a maximum of 30 inches (762 mm) in height to avoid water carryover to the reheat coil. This will ensure that the condensate formed on the fins flows into the condensate drain pan to prevent re-evaporation into the air stream.
 3. The evaporator coils shall be designed to maximize moisture removal.
 4. Coils shall be leak tested at the factory.
 5. All evaporators shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance on the complete coil assembly including casing, distributor tubes and header. Phenolic coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.
 6. Each evaporator coil shall have a separate condensate drain pan.
 7. Evaporative Coil "A"
 - a. Independent refrigeration circuit "A" shall be designed and controlled to increase the air flow over the evaporator coil to increase the sensible performance of this circuit when needed.
 - b. Circuit "A" shall also include a set of outside air and exhaust dampers to recover heat energy from the exhaust air stream when heating is required.

- c. During heating operation, circuit "A" shall operate as an exhaust air energy recovery heat pump system with a minimum COP of 4.0 at typical operating conditions.
- 8. Evaporative Coil "B"
 - a. Independent refrigeration circuit "B" shall be designed to be the primary evaporator coil to address the latent performance of the unit.
- E. Hot Gas Reheat Coils:
 - 1. Each of the two circuits shall include a refrigerant reheat coil.
 - 2. The reheat coils shall be positioned with a minimum of 8 inches (203.2 mm) clearance from the evaporator coil to help prevent water re-evaporation.
 - 3. The reheat coils shall be sized for the full heat of rejection.
 - 4. Reheat coils shall be leak tested at the factory.
 - 5. The reheat coil shall be protected by a corrosion resistive coil coating for enhanced corrosion resistance on the complete coil assembly including casing, distributor tubes and header. Phenolic coatings or fin surface only coatings are not acceptable. Manual dip processes or spray application processes will not meet specification.

2.07 FILTER SECTION

- A. General:
 - 1. All supply & return air filters are 4 inches thick.
 - 2. Air filters shall be pleated MERV 13 disposable filters.
- B. Differential Pressure Gauge:
 - 1. Provide factory installed dial type differential pressure gauge, flush mounted with casing outer wall, and fully piped to both sides of each filter to indicate status.
 - 2. Maintain plus/minus 5 percent accuracy within operating limits of 20 degrees F to 120 degrees F.

2.08 MIXING BOX AND DAMPER SECTION

- A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor, return, and exhaust air.
- B. Damper Blades:
 - 1. Shall be low leakage flat metal control dampers
 - 2. All dampers shall be a parallel blade damper with blade and jamb seals.
 - 3. Dampers shall have an AMCA leakage classification of 1A.
 - 4. Dampers shall be motorized and proportional modulating.
 - 5. The unit controller shall automatically adjust the dampers to maintain the specified flow rates through the use of integral flow measurement devices.
 - 6. Dampers shall be controlled by a fully modulating actuator.

2.09 TOTAL ENERGY RECOVERY WHEEL SECTION

- A. Unit shall contain an energy recovery cabinet with back outside air opening, back exhaust air opening, top return air opening, and top supply air opening.
- B. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings.
- C. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals.

- D. Certified in accordance with AHRI 1060 (I-P) and UL 1812 for mechanical, electrical, and fire safety.
- E. Wheel Construction:
 - 1. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
 - 2. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.
 - 3. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.
 - 4. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The energy transfer media shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
 - 5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
 - 6. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.
- F. Maintenance and Access Features:
 - 1. Access doors upstream and downstream of the wheel cassette.
 - 2. Wheel frame shall slide out for service and removal from the cabinet.
 - 3. Energy recovery wheel access shall be through service access door with piano hinges and quarter turn button fasteners.
 - 4. Adequate space for cleaning, service, and maintenance.
- G. Controls:
 - 1. Wheel Control: Damper control of recovery capacity to 40 percent of initial total recovery capacity.
 - 2. Unit shall include energy recovery wheel defrost control to periodically stop the wheel rotation, which allows the warm exhaust air to defrost the wheel. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation.
 - 3. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contacts for field indication of wheel rotation.

2.10 REMOTE AIR COOLED CONDENSER

- A. Description:
 - 1. The system shall be able to reject all the recovered heat (T.H.R.) from both circuit A and circuit B to the outdoor condenser. The outdoor condenser shall have dual headers.
- B. Cabinet Construction:
 - 1. The remote air-cooled condenser cabinet shall be constructed of G90 galvanized steel.
- C. Refrigerant System:
 - 1. The system's operating refrigerant shall match the refrigerant used by the dehumidifier in Section 2.06 above.
- D. Coils:
 - 1. Round Tube Coils-Enhanced tubing with advanced sinusoidal fin design
 - 2. Coils shall be factory leak-tested and sealed with caps.
 - 3. The condenser coil shall be fabricated from seamless drawn copper. Aluminum tubes will not be allowed.
 - 4. The fin surface on the refrigerant coils shall be continuous plate type aluminum.
- E. Fans:
 - 1. Swept fan blades are designed as part of the motor assemblies, not an addition to them.
 - 2. Fan guards shall be heavy-gauge, closed-mesh steel wire with vinyl coating. Guards shall be contoured for maximum rigidity.

2.11 ELECTRICAL

- A. Dehumidification Unit:
 - 1. The isolated electrical compartment shall include a hinged access door.
 - 2. Electrical compartment shall be rated NEMA 4 weatherproof.
 - 3. The dehumidification unit shall be provided with a single point power connection to serve controls, fans, electric heater (if provided), and compressors, factory wired to the power connection lug set.
 - 4. The high and low voltage electrical components shall be located in separate sections with individual access doors.
 - 5. The electrical controls shall include low-voltage transformers to supply 24 VAC control power for the unit.
 - 6. Safeties must include compressor high pressure cutouts per circuit with manual reset.
 - 7. Safeties must include compressor low pressure cutouts per circuit with automatic reset.
 - 8. Safeties must include an anti-short cycling timer to protect against the compressor from cycling on and off.
 - 9. Electrical nameplate on the unit shall include, but not limited to the MCA (Minimum Circuit Ampacity), the MOPD (Maximum Over-Current Protection Device) and the Short Circuit Current Rating (SCCR).
 - 10. The units shall be compatible with the electrical voltage, phase and hertz requirements as indicated on the dehumidifier schedule.
 - 11. The unit shall be equipped from the factory with a non-fused disconnect switch.
- B. Remote Condenser:
 - 1. The remote air-cooled condenser shall be provided with a weatherproof electrical panel with factory mounted door interrupt disconnect switch.
 - 2. Motor lead raceways shall be fully enclosed to protect wiring.

3. Electrical nameplate on the unit shall include, but not limited to the MCA (Minimum Circuit Ampacity), the MOPD (Maximum Over-Current Protection Device) and the Short Circuit Current Rating (SCCR).
4. The units shall be compatible with the electrical voltage, phase and hertz requirements as indicated on the dehumidifier schedule.
5. The unit shall be equipped from the factory with a non-fused disconnect switch.

2.12 CONTROLS

- A. Factory Installed Controls:
 1. A digital control system using a microprocessor shall be used to accurately and precisely control the dehumidification system and the space environment.
 2. The controller shall provide precise system control and feature an easy-to-read display which indicates actual operating conditions and set points.
 3. The controller shall have a built-in occupancy timer.
 4. The integral control system shall maintain the correct proportions of return air, supply, exhaust and ventilation air.
 5. Up to five modes of outdoor air flow rates can be programmed. Negative pressure in the space to be maintained via modulating exhaust blowers in each mode.
 6. The fan static pressure, outdoor air flow and exhaust flow can be directly read at the unit's controller.
- B. Building Management System (BMS) Compatibility shall be provided through one of the following communication protocols:
 1. BACnet MS/TP.
 2. BACnet Ethernet.
 3. LonWorks.
 4. Modbus (RTU and TCP/IP).
 5. The engineer shall review and approve the points list available in the unit.
- C. The contractor responsible for the BMS integration shall be responsible for programming the building management system to the points list provided by the dehumidifier manufacturer & engineer.
- D. Compressor safety trips shall be recorded by the controller and include pressures, date, time of day and the ambient condition if available.
- E. Emergency System Shutdown
 1. Terminal points are available for a binary contact closure by others to control unit shut down by a smoke detector or another similar device.
 2. An open contact in the 24 VAC circuit shall deactivate motors, fans and compressors.
- F. Unit shall include a high water level switch in the drain pan.
- G. Remote condenser fan(s) shall be controlled based on the refrigerant head pressure.
- H. Remote condenser shall continue to operate and automatically maintain condensing temperature at ambient conditions as low as -20°F (-17°C) Control
- I. Remote condenser fans shall operate based on the refrigerant pressure measured at the condenser.

2.13 SENSORS

- A. Temperature and humidity sensor:
 1. Factory installed in the return of the unit.

- B. Unit shall be equipped with an airflow switch to prevent the compressors from starting or operating on loss of airflow.
- C. A pressure switch to prove air supply for combustion shall be provided with gas heaters.
- D. Barometric pressure transducer shall be provided for room pressure control to maintain the zones pressure with varying amounts of outdoor air.
- E. Internal pressure transducer factory installed inside dehumidifier.
- F. Outdoor pressure transducer supplied by factory and field installed by contractor along with the tubing.
- G. The dehumidifier shall have internal transducers for monitoring refrigerant pressures.
- H. A water temperature sensor and well shall be provided for each pool or spa water loop. The sensor(s) shall be installed by the mechanical contractor in the main water loop upstream of the pool heater and dehumidifier. Constant water flow is required across the sensor.
- I. Each circuit in the air-cooled remote condenser shall be equipped with a refrigerant pressure transducer.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Start up and maintenance requirements shall be complied with to ensure safe and correct operation of the unit.
- C. Do not operate dehumidifier for temporary cooling, heating, or dehumidification during construction.
- D. Do not begin installation until wall openings and rough-in have been properly prepared.
- E. Bolt sections together with gaskets.
- F. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
- G. Provide fixed sheaves required for final air balance.
- H. Make connections to coils with unions or flanges.
- I. Hydronic Coils:
 - 1. Connect water supply to leaving air side of coil (counterflow arrangement).
 - 2. Provide with 2-way modulating control valve on the return water side.
 - 3. Provide shut-off valve on supply line and lockshield balancing valve with memory stop on return line.
 - 4. Locate water supply at bottom of supply header and return water connection at top.
 - 5. Provide manual air vents at high points complete with stop valve.
 - 6. Ensure water coils are drainable and provide drain connection at low points.
- J. Refrigerant Coils: Provide sight glass in liquid line within 12 inches of coil.
- K. Cooling Coils:
 - 1. Pipe drain and overflow to nearest floor drain.

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.
- B. Coordination of Other Tests and Inspections:

1. See Section 230593.

3.03 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform systems startup.
 1. Manufacturer's field representative shall be factory trained.
- B. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations.
- C. Adjust for proper operation within manufacturer's published tolerances.

3.04 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals for closeout submittals.
- B. See Section 017900 - Demonstration and Training for additional requirements.
- C. Demonstrate proper operation of equipment to Owner's designated representative.
- D. Training: Train Owner's personnel on operation and maintenance of system.
 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 2. Provide minimum of four hours of training.

3.05 MAINTAINENCE NOTES

- A. The following information shall be clearly identified to the owner's representative upon substantial completion:
 1. Monthly Service Requirements:
 - a. Check and replace the air filters in the return duct and the outdoor air duct.
 - b. Check for dirty coils in the dehumidifier. Clean them if necessary.
 2. Bi-Yearly Service Requirements:
 - a. Check the blower belts for wear or glazing. Tighten or replace them if necessary. Do not use belt dressing compound.
 - b. Check and tighten all field and factory electrical connections.
 - c. Check for dirty coils in the dehumidifier and the optional remote condenser.
 - d. Check and clean the drain pans and blow out the condensate drain line. If the drain is plugged, water will back up into the dehumidifier and flood the mechanical room.
 - e. Check and adjust the air flow per specifications. Dirty ducts, filters, and coils may have reduced the total air volume.
 - f. Check the operating pressures of the refrigeration circuits.
 - g. Check the current draw of each blower motor.
 - h. Check the current draw of each compressor.
 - i. Lubricate the blower motor(s).
 - j. Lubricate the supply blower bearings.

END OF SECTION 237314

SECTION 237416
PACKAGED OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL**1.01 SUMMARY**

- A. This section includes units for outdoor installation. Integral Energy Recovery device shall be a rotary air-to-air total enthalpy wheel. Integral heat source shall be air-source heat pump. Integral cooling source shall be air-source heat pump. Airflow arrangement shall be Outdoor Air with Recirculation. Each unit shall incorporate additional product requirements as listed in Section 2 of this specification.

1.02 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: For each type or model include the following:
1. Complete fan performance curves for both Supply Air and Exhaust Air, with system operating conditions indicated, as tested in an AMCA certified chamber.
 2. Sound performance data for both Supply Air and Exhaust Air, as tested in an AMCA certified chamber.
 3. Motor ratings, electrical characteristics and motor and fan accessories.
 4. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
 5. Estimated gross weight of each installed unit.
 6. Installation, Operating and Maintenance manual (IOM) for each model.
 7. Microprocessor Controller (DDC) specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.
 8. Energy wheel performance data for both summer and winter operation.
 9. **Complete curb information including curb construction, dimensions, and weights.**
- C. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- D. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- E. Specimen Warranty: Submit sample of manufacturer's warranty.
- F. Manufacturer's Instructions: Include installation instructions.
- G. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 016000 - Product Requirements for additional provisions.
 2. Extra Filters: Two sets for each unit.

1.03 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Source Limitations: Obtain unit with all appurtenant components or accessories from a single manufacturer.

- C. For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.
- D. Product Options: Drawings must indicate size, profiles and dimensional requirements of unit and are to be based on the specific system indicated. Refer to Division 1 Section "Product Requirements".
- E. End of line test with full report available upon request.
- F. Certifications
 - 1. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2023.
 - 2. AHRI 270 - Sound Performance Rating of Outdoor Unitary Equipment 2015, with Addendum.
 - 3. ASHRAE 15 - Safety Standard for Mechanical Refrigeration.
 - 4. Blowers shall be AMCA Certified for air flow.
 - 5. Entire unit shall be ETL Certified per U.L. and bear an ETL sticker.
 - 6. Energy Wheel shall be AHRI Certified, per Standard 1060.

1.04 COORDINATION

- A. Coordinate size and location of all building penetrations required for installation of each unit and associated plumbing and electrical systems.
- B. Coordinate location of water system fittings to ensure correct positioning for connection to the water coil and condensate drain pipe.
- C. Coordinate sequencing of construction of associated plumbing, HVAC, electrical supply, roofing contractor.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect units from physical damage by storing off site unit roof mounting curbs are in place and ready for immediate installation of units.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:
 - 1. AAON: www.aaon.com/#sle.
 - 2. Carrier Global Corporation: www.carrier.com/#sle.
 - 3. York, a brand of Johnson Controls International, PLC: www.york.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.

2.02 ROOFTOP UNITS

- A. General Description
 - 1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, reheat coil, electric heaters, exhaust fans, energy recovery wheels, and unit controls.
 - 2. Unit shall be factory assembled and tested including leak testing of the DX coils, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment's literature pocket.

3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including electrical and controls components.
5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.
6. Installation, Operation, and Maintenance manual shall be supplied within the unit.
7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

B. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.
4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.
6. Access to filters, dampers, cooling coils, reheat coil, energy recovery wheels, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless steel piano hinges shall be included on the doors.
7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.
8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.
9. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.
10. Unit shall include lifting lugs on the top of the unit.
11. Unit base pan shall be provided with 1/2 inch thick foam insulation.

C. Electrical

1. Unit shall have a 5kAIC SCCR.
2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

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3. Air-source heat pump shall include a defrost cycle to prevent frost accumulation on the outdoor coil during heat pump heating operation. Defrost cycle shall begin when outdoor coil temperature is below a fixed setpoint and have a fixed 10 minute run time, or end when the outdoor coil temperature is above a fixed setpoint. Defrost timer, with 30/60/90 minute selectable defrost cycle interval time, shall be factory installed in the controls compartment. During defrost cycle all compressors shall energize, reversing valve shall de-energize, and auxiliary heat shall energize.
 4. Unit shall be provided with a factory installed and factory wired 115V, 12 amp GFI outlet disconnect switch in the unit control panel.
- D. Supply Fans
1. Unit shall include direct drive, unhooded, backward curved, plenum supply fans.
 2. Blowers and motors shall be dynamically balance and mounted on rubber isolators.
- E. Exhaust Fans
1. Exhaust dampers shall be sized for 100% relief.
 2. Fans and motors shall be dynamically balanced.
 3. Unit shall include barometric relief dampers.
 4. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn lockable handles.
- F. Cooling Coils
1. Evaporator Coils
 - a. Coils shall be designed for use with R-454B refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.
 - b. Coil shall be standard capacity.
 - c. Coils shall be hydrogen or helium leak tested.
 - d. Coils shall be furnished with factory installed expansion valves.
 2. Unit shall be factory charged with R-454B refrigerant.
 3. Refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
 4. If unit is equipped with multiple refrigeration circuits, lead refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
 5. Unit shall be configured as an air-source heat pump. Each refrigeration circuit shall be equipped with a factory installed liquid line filter drier with check valve, reversing valve, accumulator, and expansion valves on both the indoor and outdoor coils. Reversing valve shall energize during the heat pump cooling mode of operation.
 6. Each refrigeration circuit shall be equipped with a liquid line sight glass.
 7. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.
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8. Heat pump outdoor coil shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
- G. Filters
1. Unit shall include 4 inch thick, pleated panel filters with an ASHRAEMERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with an ASHRAE MERV rating of 8, upstream of the 4 inch standard filters.
 2. Unit shall include a clogged filter switch.
 3. Unit shall include a Magnehelic gauge mounted in the controls compartment.
- H. Outside Air/Economizer
1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return DDC actuator. Unit shall include outside air opening bird screen and outside air hood. Unit, except for horizontal series, shall also include barometric relief dampers.
- I. Energy Recovery (as per schedule)
1. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.
 2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
 3. Units shall contain two 64 in. energy recovery wheels with a 2 in. minimum media thickness oriented in a "V" formation in the factory assembled cabinet.
 4. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.
 5. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory. The first 12 months from the date of equipment startup, or 18 months from the date of original equipment shipment from the factory, whichever is less, shall be covered under the standard AAON limited parts warranty. The remaining period of the warranty shall be covered by Airxchange. The 5 year warranty applies to all parts and components of the cassette, with the exception of the motor, which shall carry an 18 month warranty. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided the Airxchange written instructions for Installation, Operation, and Maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts. Refer to the Airxchange Energy Recovery Cassette Limited Warranty Certificate.
 6. Hinged service access doors shall allow access to the wheel.
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7. Unit shall include energy recovery wheel defrost control which includes an adjustable temperature sensor and timer wired to periodically stop the wheel rotation, which allows the warm exhaust air to defrost the wheel.
- J. Controls
 1. Factory Installed and Factory Provided Controller shall not be provided. Equipment shall be provided with individual controls for components listed above to have factory control devices (i.e. refrigeration system, Energy Recovery, etc.)
 2. BMS shall control all unit functions unless described herein as components listed to have factory control devices (i.e. refrigeration system, Energy Recovery, etc.)
 3. Provided controls shall be capable of controlling all features and options of the component listed. Controller shall be factory installed in the unit controls compartment and factory tested.
 4. With modulating hot gas reheat option, a field installed space humidity sensor and a field installed supply air temperature sensor shall be furnished to control the amount of reheat during dehumidification. Supply air temperature and space humidity setpoint shall be field adjustable.
 5. Unit controls shall include a diagnostics package with suction and discharge pressure transducers, temperature sensors that monitor compressor performance and current sensors to confirm mode of operation.
- K. Accessories
 1. Unit shall be provided with a safety shutdown terminal block for field installation of a smoke detector which shuts off the unit's control circuit.

2.03 CURBS

- A. Curbs shall be provided as indicated on drawings
- B. This subsection includes both standard curbs, split curbs, as well as side discharge plenum curbs.
 1. Curbs shall to be fully gasketed between the curb top and unit bottom with the curb providing full perimeter support, cross structure support and air seal for the unit. Curb gasket shall be furnished within the control compartment of the rooftop unit to be mounted on the curb immediately before mounting of the rooftop unit.
 2. Knockdown curb (with duct support rails) shall be factory furnished for field assembly.
 3. Solid bottom curb shall be factory assembled and fully lined with curb rated 1 inch fiberglass insulation and include a wood nailer strip.
 4. All curbs shall bear directly on the roof structure and shall be flashed and waterproofed into the roof's membrane waterproofing system by the installing contractor.
 5. All curbs shall have factory installed lifting points.
 6. Curb sides and ends shall be capable of accepting 2" external insulation furnished and installed by the roofing contractor or factory installed.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Prior to start of installation, examine area and conditions to verify correct location for compliance with installation tolerances and other conditions affecting unit performance. See unit IOM.
- B. Examine roughing-in of plumbing, electrical and HVAC services to verify actual location and compliance with unit requirements. See unit IOM.

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

3.02 INSTALLATION

- A. Installation shall be accomplished in accordance with these written specifications, project drawings, manufacturer's installation instructions as documented in manufacturer's IOM, Best Practices and all applicable building codes.

3.03 CONNECTIONS

- A. In all cases, industry Best Practices shall be incorporated. Connections are to be made subject to the installation requirements shown above.
- B. Piping installation requirements are specified in Division 22 (Plumbing). Drawings indicate general arrangement of piping, fittings and specialties.
- C. Duct installation and connection requirements are specified in Division 23 of this document.
- D. Electrical installation requirements are specified in Division 26 of this document.

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect field assembled components and equipment installation, to include electrical and piping connections. Report results to A / E in writing. Inspection must include a complete startup checklist to include (as a minimum) the following: Completed Start-Up Checklists as found in manufacturer's IOM.

3.05 START-UP SERVICE

- A. Engage a factory authorized service representative to perform startup service. Clean entire unit, comb coil fins as necessary, install clean filters. Measure and record electrical values for voltage and amperage. Refer to Division 23 "Testing, Adjusting and Balancing" and comply with provisions therein.

3.06 DEMONSTRATION AND TRAINING

- A. Training: Train Owner's personnel on operation and maintenance of system.
1. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the entire unit. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.
 2. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 3. Provide minimum of two hours of training.

END OF SECTION 237416

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**SECTION 238200
CONVECTION HEATING AND COOLING UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic finned tube radiation enclosures.
- B. Hydronic unit heaters.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230719 - HVAC Piping Insulation.
- C. Section 230913 - Instrumentation and Control Devices for HVAC.
- D. Section 230993 - Sequence of Operations for HVAC Controls.
- E. Section 232114 - Hydronic Specialties.
- F. Section 233100 - HVAC Ducts and Casings.

1.03 REFERENCE STANDARDS

- A. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001, with Addenda (2011).
- A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); Current Edition.
- B. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications; Most Recent Edition Cited by Referring Code or Reference Standard.
- C. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2026).
- E. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- F. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.
- G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 013300 – Submittal Procedures for submittal procedures.
- B. Product Data: Provide typical catalog of information including arrangements.
- C. Shop Drawings:
 - 1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
 - 2. Indicate air coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.

3. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
4. Submit the following for fan-coil units indicating:
 - a. Overall dimensions including installation, operation, and service clearances.
 - b. Lift points, recommendations, and center of gravity.
 - c. Unit shipping, installation, and operating weights including dimensions.
 - d. Fan curves with specified operating point clearly plotted.
 - e. Safety and start-up instructions.
5. Indicate mechanical and electrical service locations and requirements.
- D. Selection Samples: For each finish product specified, color chart representing manufacturer's full range of available colors.
- E. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.
- F. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- G. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
- H. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- I. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.07 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.

PART 2 PRODUCTS

2.01 HYDRONIC FINNED TUBE RADIATION ENCLOSURES

- A. Manufacturers:
 1. Zehnder Rittling: www.rittling.com/#sle.
 2. Sterling Hydronics, a Mestek Company: www.sterlingheat.com/#sle.
 3. Modine Manufacturing Company: www.modineHVAC.com/#sle.
 4. Substitutions: See Section 016000 - Product Requirements.
- B. Construction: 18 gauge, 0.0478 inch sheet steel up to 18 inches in height, 16 gauge, 0.0598 inch sheet steel over 18 inches in height or aluminum as detailed, with easily jointed components for wall to wall installation.
- C. Finish: Factory applied baked primer coat.
 1. Basis of design: Zehnder Rittling factory color "Ivory".
- D. Damper: Where not thermostatically controlled, provide knob-operated internal damper at enclosure air outlet.

- E. Access Doors: For otherwise inaccessible valves, provide factory-made permanently hinged access doors, 6 by 7 inch minimum size, integral with cabinet.

2.02 HYDRONIC UNIT HEATERS

- A. Manufacturers:
 - 1. Zehnder Rittling; www.zehnder-rittling.com/#sle.
 - 2. Sterling Hydronics, a Mestek Company; www.sterlingheat.com/#sle.
 - 3. Trane Technologies, PLC; www.trane.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.
- C. Perform factory run test under normal operating conditions, water, and steam flow rates.
- D. Casing: Minimum 18 gauge, 0.0478 inch thick sheet steel casing with threaded pipe connections for hanger rods for horizontal models and minimum 18 gauge, 0.0478 inch thick sheet steel top and bottom plates for vertical projection models.
- E. Finish: Factory applied baked primer coat.
- F. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.
- G. Air Outlet: Adjustable pattern diffuser on vertical projection models and two- or four- way louvers on horizontal projection models.
- H. Control: Local solid state disconnect switch with electropneumatic thermostat.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that surfaces are suitable for installation.
- B. Verify that field measurements are as indicated on drawings.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Install equipment exposed to finished areas after walls and ceilings are finished and painted.
- C. Do not damage equipment or finishes.
- D. Unit Heaters:
 - 1. Hang from building structure, with pipe hangers anchored to building, not from piping or electrical conduit.
 - 2. Mount as high as possible to maintain greatest headroom unless otherwise indicated.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements for additional requirements.

3.04 CLEANING

- A. After construction and painting is completed, clean exposed surfaces of units.
- B. Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.

3.05 CLOSEOUT ACTIVITIES

- A. See Section 017700 – Closeout Procedures for closeout submittals.
- B. See Section 017900 - Demonstration and Training for additional requirements.

END OF SECTION 238200

**SECTION 238300
RADIANT HEATING AND COOLING UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic radiant panel heaters.

1.02 RELATED REQUIREMENTS

- A. Section 083100 - ACCESS DOORS AND PANELS.
- B. Section 230719 - HVAC Piping Insulation.
- C. Section 230993 - Sequence of Operations for HVAC Controls.
- D. Section 232113 - Hydronic Piping.
- E. Section 232114 - Hydronic Specialties.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 138 - Method of Testing for Rating Ceiling Panels for Sensible Heating and Cooling; 2021.
- B. ASTM B75/B75M - Standard Specification for Seamless Copper Tube; 2026.
- C. DIN EN 14037-2 - Free Hanging Heating and Cooling Surfaces for Water with a Temperature Below 120 Degrees C - Part 2: Pre-Fabricated Ceiling Mounted Radiant Panels for Space Heating - Test Method for Thermal Output; 2016.
- D. DIN EN 14037-3 - Free Hanging Heating and Cooling Surfaces for Water with a Temperature Below 120 Degrees C - Part 3: Prefabricated Ceiling Mounted Radiant Panels for Space Heating - Rating Method and Evaluation of Radiant Thermal Output; 2016.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for ceiling panel heaters.
- C. Shop Drawings: Indicate ceiling panel heater layout, thermostats, controls, and branch circuit connections.
- D. Manufacturer's Installation Instructions: Indicate installation instructions and recommendations.
- E. Project Record Documents: Record actual locations of ceiling panel heaters and thermostats.
- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions of equipment and controls, installation instructions, maintenance and repair data, and parts listings.
- G. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- H. Maintenance Data:
 - 1. Include repair methods and parts list of components.
 - 2. See Section 016000 - Product Requirements, for additional provisions.

1.06 QUALITY ASSURANCE

- A. Manufacturer of the radiant heating ceiling system shall have a minimum of 5 years of similar installations.
- B. Radiant ceiling panels and accessories shall be rated and tested for pressures as shown on drawings and manufacturers technical documentation.
- C. Use same brand of Manufacturer throughout, unless otherwise specified.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. General:
 - 1. Comply with Division 01 Product Requirements Section.
- B. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
- C. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.
- D. Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions as recommended by the manufacturer.
- E. Protect all units before, during and after installation. Damaged materials due to improper protection shall be cause for rejection.

1.08 WARRANTY

- A. Radiant ceiling manufacturer to supply 5 year warranty from date of shipment.
- B. See Section 017800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS**2.01 HYDRONIC RADIANT PANEL HEATERS**

- A. Manufacturers:
 - 1. Zehnder Rittling; www.zehnder-rittling.com/#sle.
 - 2. Price Industries; www.price-hvac.com/#sle.
 - 3. Sterling Hydronics a Mestek Company; www.sterlingheat.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Modular Radiant Ceiling Panels: Heat sinks located behind panel, transfer heat between copper tubes and panel face, and radiate heat to zone.
 - 1. Water Tubes:
 - a. 1/2" nominal Type L (5/8" OD) copper tubing, snapped into tube saddles and mechanically fastened to the aluminum extrusion.
 - b. 1/2" nominal copper return bends and interconnectors are both with flared ends and supplied loose. Quantity based upon the number of tubes wide for each panel.
 - c. Activation of ceiling panel to include graphite activation with 1/2" copper tubing embedded in the sandwich. Cooper tubing shall be single continuous tube and factory pressure tested prior to shipment. Soldered on ubends are not acceptable.
 - d. Radiant panels shall be 2-pipe.
 - 2. Heat Sink Construction:
 - a. Radiant ceiling panels to be constructed from 0.04" aluminum material.
 - b. Mechanically fasten extruded aluminum and copper pipe to heat sink.
 - c. Provide non-hardening heat transfer paste between tubing, heat sink, and panel.
 - 3. Finish:

- a. Radiant ceiling panel surface to be coated with highly emissive powder coat paint for optimal radiative properties.
 - b. Color to be selected from manufacturer's full color chart.
 - c. Maintain optimal radiative properties, durability, and cleanability.
4. Water Pressure Drop and Heating Output Data: Derive from factory testing in accordance with ASHRAE Std 138 or DIN EN 14037, Parts 2 and 3.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Hydronic Radiant Ceiling Panel Heaters:
 1. Examine areas to receive radiant heating units for compliance with requirements for installation tolerances and other conditions affecting performance.
 2. Examine roughing-in for hydronic piping connections to verify actual locations prior to installation.
 3. Ensure surfaces are level and plumb.
 4. Proceed with installation only after unsatisfactory conditions are corrected.

3.02 PREPARATION

- A. Clean all surfaces prior to installation.

3.03 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Hydronic Radiant Ceiling Panel Heaters:
 1. Install level and plumb.
 2. Install radiant panel level and plumb. Maintain sufficient clearance for normal services, maintenance, or in accordance with construction drawings.
 3. Suspend from structure.
 4. Support in grid-type suspended ceiling using grid as support element as follows:
 - a. Install a minimum of four ceiling support system rods or wires for each panel, located not more than 6 inches from panel corners.
 - b. Fasten support clips to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
 - c. Install at least one independent support rod or wire from structure to tab on panel with breaking strength of the weight of panel at a safety factor of 3.
 5. Piping installation requirements are specified in other Division 23 Sections. Drawings indicated general arrangement of piping, fittings, and specialties.
 6. Install piping adjacent to radiant panels to allow for service and maintenance.
 7. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
 8. Provide tamper-proof, balancing valve with memory stop on return piping.
 9. Provide float operated automatic air vents with stop valve.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Provide manufacturer's field representative to instruct and observe.
- C. Hydronic Radiant Ceiling Panel Heaters:
 1. Inspect for damage to finish.
 2. Repair damaged finish to match original finish.
 3. Perform the following field tests, inspections, and prepare test reports:

- a. Leak Test:
 - 1) After installation, fill water tubes, and test for leaks.
 - 2) Repair leaks and retest until no leaks exist.
- b. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
- c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- 4. Remove and replace damaged and malfunctioning controls and equipment and retest as specified above.

3.05 CLEANING

- A. Radiant Ceiling Panel Heaters: Remove paint splatters, other spots, dirt, and debris.
- B. Remove protective film coating before startup of the system.

3.06 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Demonstrate Operation of Controls for the following Equipment:
 - 1. Hydronic Radiant Ceiling Panel Heaters.

3.07 PROTECTION

- A. Protect installed products from damage until Date of Substantial Completion.

END OF SECTION 238300

**SECTION 260010
GENERAL PROVISIONS FOR ELECTRICAL WORK**

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. The work included in this Contract is shown on the drawings and described in these specifications. It consists of furnishing all labor, material, services, supervision and connection of all systems shown and/or specified including the requirements of:
 - 1. DIVISION 00 - BIDDING AND CONTRACT REQUIREMENTS
 - 2. DIVISION 1 - GENERAL REQUIREMENT
 - 3. DIVISION 26,27,28 - GENERAL REQUIREMENT
- B. Contractor is responsible to review and understand all drawings and all work of all trades to ensure a complete and thorough project.
- C. Provide all labor, tools, materials, equipment, coordination, and plans necessary for installation and proper operation of the electrical systems.
- D. Contract drawings and specifications are complementary and must be so used to ascertain all requirements of the work.

1.02 DEFINITIONS

- A. Provide, furnish, install, and furnish and install shall have the same meaning. That is, the Contractor shall purchase, transport to the site and install all required components of the work unless specifically stated otherwise in the contract documents.
- B. Wiring pertains to raceway, fittings, conductors, terminations, hangers, supports, etc. as required to form a complete system.

1.03 DRAWINGS AND SPECIFICATIONS

- A. The plans are diagrammatic and indicate only the sizes and general arrangement of conduit, devices, and equipment; exact locations of all elements shall be determined as work progresses, in cooperation with the work of other trades. It is not intended to show every item of work or minor piece of equipment, but every item shall be furnished and installed without additional remuneration as necessary to complete the system in accordance with the best practice of the trade.
- B. As previously stated, the exact locations of electrical devices and equipment are diagrammatic. The owner may request for any devices or equipment to be installed at different locations than what is indicated on the drawings in a specific area or room. It is the responsibility of the Electrical Contractor to coordinate the locations of devices in all areas prior to installation.

1.04 PRODUCT EQUIVALENTS

- A. Where, in these specifications or on drawings, certain kinds, types, brands, or manufacturers of materials are named, they shall be regarded as required standard of quality. Where two or more are named these are presumed to be equal, and Contractor may select one of those items.
- B. If Contractor desires to use any kind, type, brand, or manufacturer of material other than those named in specification, he may submit the request for approval to the Architect well in advance of the bid date.
- C. Requests for approval of proposed equivalents will be received by Architect only from the Contractor.

- D. If the Architect approves a proposed equivalent prior to receipt of Bids, such approval will be set forth in an Addendum.
- E. After the bid opening the apparent low bidder or bidders will be notified by the Architect or Owner and shall submit to the Architect in writing, within ten (10) calendar days what equivalent kind, type, brand, or manufacture is included in bid in lieu of specified items. No equivalents will be considered after this submission.
- F. Contractor shall have burden of proving, at Contractor's own cost and expense, to satisfaction of Owner/Architect, that proposed product is similar and equal to named product. In making such determination Owner/Architect will be sole judge of objective and appearance criteria that proposed product must meet in order for it to be approved.
 - 1. Supporting data on equivalency is responsibility of bidder. For each equivalent to base specification, included in products list, submit information describing in specific detail:
 - a. Wherein it differs from quality and performance required by base specification.
 - b. Changes required in other elements of work because of equivalent.
 - c. Effect on construction schedule.
 - d. Any required license fees or royalties.
 - e. Availability of maintenance service, and source of replacement materials.
 - f. Such other information as may be required by Owner.
- G. Owner, through Architect, shall be judge of acceptability of proposed equivalents. Risk of whether bid equivalents will be accepted is borne by Contractor.
- H. Submission of an equivalent product and/or material constitutes a representation that Contractor:
 - 1. Has investigated proposed product and determined it is equal to or superior in all respects to that specified.
 - 2. Will provide same warranties or bonds for equivalent as for product specified.
 - 3. Will coordinate installation of an accepted equivalent into work and make such other changes as may be required to make work complete in all respects.
 - 4. Waives all claims for additional costs, under his responsibility, which may subsequently become apparent.
 - 5. Will provide, at own cost and expense, any different quantity and/or arrangement of ductwork, piping, wiring, conduit or any part of work from that specified, detailed or indicated in Contract Documents if required for proper installation of an approved equivalent.
 - 6. Will provide, at own cost and expense, all such revision and redesign and all new drawings and details required by Architect for approval if proposed equivalent product requires a revision or redesign of any part of work covered by this contract.
- I. Contractor must sign the "Equivalent Certification" following this specification section and deliver it to the Architect along with a complete list of proposed equivalents within ten (10) calendar days after notification from the Architect or Owner. This is mandatory and must be done prior to award of contracts.

1.05 APPLICABLE STANDARDS

- A. All equipment shall bear the UL label.
- B. The latest edition of the following minimum standards shall apply wherever applicable:
 - 1. American Standards Association
 - 2. American Society for Testing Materials
 - 3. Electrical Testing Laboratories, Inc.

4. Institute of Electrical and Electronic Engineers
 5. Insulated Power Cable for Engineers Association
 6. Occupational Safety and Health Act
 7. National Electric Code
 8. National Electrical Manufacturers Association
 9. National Electrical Safety Code
 10. National Fire Protection Association
 11. Underwriters Laboratories, Inc.
 12. Power company standards and regulations.
 13. Local and state codes.
- C. In the event there are conflicts between specifications and standards, standards shall govern unless specifications are in excess of standards.

1.06 PERMITS AND INSPECTIONS

- A. Permits: The Contractor shall apply for and pay the cost for any local permits necessary for the work of this contract.
- B. Inspections: The Contractor shall be responsible for obtaining a 3rd party electrical inspection of and the certificate by the approved inspection agency for the entire electrical system.
- C. The undertaking of periodic inspections by the Owner or Engineer shall not be construed as supervision of actual construction. The Owner or Engineer is not responsible for providing a safe place of work for the Contractor, Contractor's employees, suppliers or subcontractors for access, visits, use, work, travel or occupancy by any person.

1.07 CODES AND REGULATIONS

- A. Comply with all applicable rules and regulations of the municipal laws and ordinances and latest revisions thereof. All work shall be done in full conformity with the requirements of all authorities having jurisdiction. Modifications required by the above authorities will be made without additional charges to the Owner. Where alterations to and/or deviations from the Contract Documents are required by the authorities, report the requirements to the Engineer and secure approval before work is started.
- B. Furnish and file with the proper authorities, all drawings required by them in connection with the work. Obtain all permits, licenses, and inspections and pay all legal and proper fees and charges in this connection.
- C. Should any work shown or specified be of lighter or smaller material than Code requires, same shall be executed in strict accordance with the regulations.
- D. Heavier or larger size material than Code requires shall be furnished and installed, if required by the Plans and Specifications.
- E. This Contractor shall have the electrical work inspected from time to time by authorized inspectors and shall pay all expense incurred by same. At the completion of the work, the Contractor shall furnish a Certificate of Approval, in triplicate, indicating full approval of the work furnished and installed in this Contract from the local authority having jurisdiction.
- F. Equipment and components parts thereof shall bear manufacturer's name-plate, giving manufacturer's name, size, type and model number or serial number, electrical characteristic to facilitate maintenance and replacements. Name plates of distributors or contractors are not acceptable.

- G. Engineer will have privilege of stopping any work or use of any material that in his opinion is not being properly installed and each Contractor shall remove all materials delivered, or work erected, which does not comply with Contract Drawings and Specifications, and replace with proper materials, or correct such work as directed by the Engineer, at no additional cost to Owner.
- H. If equipment or materials are installed before proper approvals have been obtained, each Contractor shall be liable for their removal and replacement including work of other trades affected by such work, at no additional cost to Owner, if such items do not meet intent of the Drawings and Specifications.

1.08 RECORD DRAWINGS

- A. The Electrical Contractor shall keep an accurate location record of all underground and concealed piping, and of all changes from the original design. He is required to furnish this information to the Engineer prior to his application for final payment.
 - 1. Submit prior to final acceptance inspection, one complete marked-up set of reproducible engineering design drawings.
 - a. Fully illustrate all revisions made by all crafts in course of work.
 - b. Include all field changes, adjustments, variances, substitutions and deletions, including all Change Orders.
 - c. Exact location of raceways, equipment and devices.
 - d. Exact size and location of underground and under floor raceways, grounding conductors and duct banks.
 - e. These drawings shall be for record purposes for Owner's use and are not considered shop drawings.
- B. At completion of the project, all changes and deviations from the Contract Documents shall be recorded by the Contractor.
- C. Four (4) corrected sets of all operating and maintenance instructions and complete parts lists bound in hard covers shall be furnished to the Owner.

1.09 SLEEVES

- A. Sleeves: furnished, set in Electrical Work; built-in under General Construction Work.
- B. Sleeves shall be as follows:
 - 1. Sleeves in floors and partitions shall be galvanized steel with lock seam joints or a manufactured conduit floor seal.
 - 2. Sleeves of extra heavy cast iron pipe or galvanized steel pipe shall be used in outside walls, foundations, and footing or manufactured compression-type wall seal (waterproof).
 - 3. Conduit sleeves shall be two (2) sizes larger than the conduit passing through it.
 - 4. Terminate sleeves flush with walls, partitions, and ceilings. Sleeves in floor shall terminate 1/4" above floors.
 - 5. Fill space between sleeve and conduit in foundation walls with oakum and caulk with lead on both sides of wall. When using pipe sleeves, fill space between sleeve and pipe with fiberglass blanket insulation when sleeve does not occur in a foundation wall.
 - 6. An approved fire stop seal shall be used when conduits penetrate fire stopping walls and floors (between fire zone).
- C. Set sleeves, obtain review of their locations in ample time to permit pouring of concrete or progressing of other construction work as scheduled.

1.10 CLEANING CONDUIT, EQUIPMENT

- A. Conduit, equipment: thoroughly cleaned of dirt, cuttings, other foreign substances. Should any conduit, other part of systems be stopped by any foreign matter, disconnect, clean wherever necessary for purpose of locating, removing obstructions. Repair work damaged in course of removing obstructions.

1.11 VIBRATION ISOLATION

- A. Vibration isolators shall prevent, as far as practicable, transmission of vibration, noise or hum to any part of building.
- B. Design isolators to suit vibration frequency to be absorbed; provide isolator units of area, distribution to obtain proper resiliency under machinery load, impact.
- C. Wiring and other electrical connections to equipment mounted on vibration isolators; made flexible with minimum 180 degree loop of "greenfield" in order to avoid restraining equipment and short circuiting vibration isolator.

1.12 BALANCED LOAD

- A. It is intended that design and features of the work as indicated will provide balanced load on the feeders and main service. Contractor shall provide material and installation to provide this balance load insofar as possible.
- B. Contractor shall take current and voltage measurements at all panels of at least 1/2 hour. Reconnections of loads shall be made when deemed necessary by the Engineers.

1.13 JOB CONDITIONS

- A. Examine site related work and surfaces before starting work of any Section. Failure to do so shall in no way relieve the Contractor of the responsibility to properly install the new work.
 - 1. Report to the Engineer, in writing, conditions, which will prevent proper provision of this work ten (10) days prior to bid date, in time for an addendum to be issued .
 - 2. Beginning work of any Section without reporting unsuitable conditions to the Engineer constitutes acceptance of conditions by the Contractor.
 - 3. Perform any required removal, repair or replacement of this work caused by unsuitable conditions at no additional cost to Owner.
 - 4. The Contractor is responsible for performing routine maintenance and cleaning of any existing equipment where he is making connections to new work and to the building where his work adds debris.
- B. Connections to existing work:
 - 1. Install new work and connect to existing work with minimum interference to existing facilities.
 - 2. Provide temporary shutdowns of existing services only with written consent of Owner at no additional charges and at time not to interfere with normal operation of existing facilities.
 - 3. Maintain continuous operation of existing facilities as required with necessary temporary connections between new and existing work.
 - 4. Do not interrupt alarm and emergency systems.
 - 5. Connect new work to existing work in neat and acceptable manner.
 - 6. Restore existing disturbed work to original condition including maintenance of wiring and continuity as required. Replace damaged or rusted conduit to which new equipment is being installed and connected.
- C. Removal and relocation of existing work.
 - 1. Disconnect, remove or relocate electrical material, equipment and other work noted and required by removal or changes in existing construction.

2. Provide new material and equipment required for relocated equipment.
3. Disconnect load and line end of conductors feeding existing equipment.
4. Remove conductors from existing raceways to be rewired.
5. Remove conductors and cap outlets on raceways to be abandoned.
6. Cut and cap abandoned floor raceways flush with concrete floor or behind walls and ceilings.
7. Dispose of removed raceways and wire.
8. Dispose of removed electrical equipment as directed by Owner. The Owner shall provide a list of equipment of the Contractor of equipment to be delivered to the Owner.

1.14 SPECIAL TOOLS AND LOOSE ITEMS

- A. Furnish to Owner at completion of work:
 1. One set of any special tools required to operate, adjust, dismantle or repair equipment furnished under any section of this Division.
 2. "Special Tools": Those not normally found in possession of mechanics or maintenance personnel.
 3. Keys
 4. Redundant components and spare parts.
- B. Deliver items to Owner and obtain receipt prior to approval of final payment.

1.15 REVIEW OF CONSTRUCTION

- A. Work may be reviewed at any time by representative of the Engineer.
- B. Advise Architect and Engineer that work is ready for review at following times:
 1. Prior to backfilling buried work.
 2. Prior to concealment of work in walls and above ceilings.
 3. When all requirements of contract have been completed.
- C. Neither backfill nor conceal work without Engineer's consent.

1.16 SHOP DRAWING SUBMITTALS

- A. Submit required shop drawings, samples and product information in accordance with Division 1, requirements and as required in the various sections of these specifications.
- B. Submittals shall show evidence of checking by the Contractor for accuracy. Product information (catalog sheets) shall indicate complete catalog number, color, accessories, etc., as well as, name of manufacturer and local distributor or manufacturer's representative.
- C. Submit for review detailed coordination drawings 3/8" or larger scale plans for all major electrical equipment and any areas of conflicts by drafting location of equipment, lighting fixtures, cable trays and conduits larger than 1-1/2" trade size. Contractor shall refer to Division 1 for preparing coordination drawings.
- D. Incomplete submittals will be rejected.
- E. Additionally, the Contractor will submit data on the following:
 1. All electrical equipment including all panelboards and switching devices (disconnects, switches, occupancy sensors, etc.).
 2. Fire stop seals used for wall penetrations.
 3. Any proposed variation in specified wiring plans and circuitry.
 4. All special items and panels, made or constructed specifically for this project, including wiring diagrams, component layout and component data or materials list.

- 5. All settings of installed equipment, such as overcurrent protection, overload settings, temperature settings, time settings, etc. This includes equipment provided by other contractors or subcontractors and connected and tested by this Contractor.
- F. All submittals of NON SPECIFIED equipment and components will be reviewed. It is the submitting Contractor's responsibility to prove compliance and not the Architect/Engineer to prove non-compliance. The submitting Contractor will be charged the prevailing wage of the reviewing Engineer for all submittals requiring over one (1) hour to review that were not originally specified.
- G. It is the Contractor's responsibility to provide submittals in an organized and timely manner so as not to delay the project schedule and hamper the work of other trades.

1.17 OPERATING INSTRUCTIONS

- A. It shall be the Contractor's responsibility to insure that the Owner's representative is given adequate instruction on the operation of all equipment prior to final payment.

1.18 TEMPORARY POWER

- A. The Contractor shall provide all temporary power to all trades throughout all phases of construction throughout the duration of this project. This will include but not be limited to temporary lighting, power outlets, temporary elevator operation, controls for temporary heating, and job trailers. Contractor shall be responsible for providing temporary power via adjacent building(s) and/or a temporary diesel fired generator and associated fuel costs. Contractor shall coordinate temporary power source with project manager prior to demolition. Contractor is responsible for all costs associated with temporary power.

PART 2 PRODUCTS

2.01 MATERIALS

- A. All materials and equipment shall be new and as specified or of equal or better quality.
- B. Basic hardware and miscellaneous items shall meet existing trade standards of quality and shall carry UL or FM listings where applicable.
- C. All equipment supplied shall be the standard equipment of the manufacturer.
- D. Multiple items such as panelboards, wiring devices, switches, breakers, raceways, etc., shall be from the same manufacturer.
- E. Drawings and specifications are based on specific manufacturer's equipment. Therefore, the Contractor shall assume all responsibility, cost and coordination involved in making any necessary revisions to apply another manufacturer's equipment, even though it may be approved as an "equal" item by the Engineer.

PART 3 EXECUTION

3.01 COORDINATION OF WORK

- A. All work shall be executed in accordance with recognized standards of workmanship. All work shall be installed in a neat and orderly manner.
- B. The Contractor shall exchange information with other Contractors and the Owner in order to insure orderly progress of the work.
- C. The Contractor must contact the Owner's representative and schedule all work ten (10) days prior to start.

- D. The Contractor shall check for possible interference before installing any items. If any work is installed, and later develops interference with other features of the design, the Contractor will be responsible to make such changes to eliminate the interference.

3.02 CEILING REMOVAL

- A. Existing ceilings which must be removed for the installation of new work or demolition of existing conditions shall be done by the Contractor. No ceiling shall be removed without prior approval of the Owner. Ceilings which must be removed shall be restored to their original condition as soon as practical and prior to final payment.
- B. The removed tile of lay-in type ceilings shall be stored either in the ceiling space or at a designated space in the building. No tiles shall be stored in the occupied space.
- C. The Contractor shall take all necessary precautions to prevent damage to the existing ceilings. All damaged ceilings shall be replaced with new ceiling construction to match the existing and to the Owner's satisfaction.

END OF SECTION 260010

**SECTION 260505
SELECTIVE DEMOLITION FOR ELECTRICAL**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Electrical demolition.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that abandoned wiring and equipment serve only abandoned facilities.
- B. Demolition drawings are based on casual field observation and existing record documents.
- C. Report discrepancies to Architect before disturbing existing installation.
- D. Beginning of demolition means installer accepts existing conditions.

3.02 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings to be removed.
- B. Coordinate utility service outages with utility company, as applicable.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.

3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Perform work for removal and disposal of equipment and materials containing toxic substances regulated under the Federal Toxic Substances Control Act (TSCA) in accordance with applicable federal, state, and local regulations. Applicable equipment and materials include, but are not limited to:
 - 1. PCB-containing electrical equipment, including transformers, capacitors, and switches.
 - 2. PCB- and DEHP-containing lighting ballasts.
 - 3. Mercury-containing lamps and tubes, including fluorescent lamps, high intensity discharge (HID), arc lamps, ultra-violet, high pressure sodium, mercury vapor, ignitron tubes, neon, and incandescent.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Remove abandoned wiring to source of supply.
- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.
- F. Disconnect and remove abandoned panelboards and distribution equipment.
- G. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

- H. Repair adjacent construction and finishes damaged during demolition and extension work.
- I. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
- J. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

3.04 CLEANING AND REPAIR

- A. See Section 017419 - Construction Waste Management and Disposal for additional requirements.
- B. Clean and repair existing materials and equipment that remain or that are to be reused.

END OF SECTION 260505

SECTION 260519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single conductor building wire.
- B. Metal-clad cable.
- C. Wiring connectors.
- D. Electrical tape.
- E. Heat shrink tubing.
- F. Oxide inhibiting compound.
- G. Wire pulling lubricant.
- H. Cable ties.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 260526 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.

1.03 REFERENCE STANDARDS

- A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013 (Reapproved 2024).
- B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2023.
- C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010, with Editorial Revision (2020).
- D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation; 2004 (Reapproved 2020).
- E. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape; 2024.
- F. ASTM D4388 - Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes; 2020.
- G. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- H. NECA 120 - Standard for Installing Armored Cable (AC) and Type Metal-Clad (MC) Cable; 2018.
- I. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy; 2021.
- J. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.
- K. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

- L. UL 44 - Thermoset-Insulated Wires and Cables; Current Edition, Including All Revisions.
- M. UL 83 - Thermoplastic-Insulated Wires and Cables; Current Edition, Including All Revisions.
- N. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.
- O. UL 486C - Splicing Wire Connectors; Current Edition, Including All Revisions.
- P. UL 486D - Sealed Wire Connector Systems; Current Edition, Including All Revisions.
- Q. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape; Current Edition, Including All Revisions.
- R. UL 1569 - Metal-Clad Cables; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
 - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conductors and cables in accordance with manufacturer's instructions.

1.08 FIELD CONDITIONS

- A. Do not install or otherwise handle thermoplastic-insulated conductors at temperatures lower than 14 degrees F, unless otherwise permitted by manufacturer's instructions. When installation below this temperature is unavoidable, notify Architect and obtain direction before proceeding with work.

PART 2 PRODUCTS

2.01 CONDUCTOR AND CABLE APPLICATIONS

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
- C. Nonmetallic-sheathed cable is not permitted.
- D. Underground feeder and branch-circuit cable is not permitted.
- E. Service entrance cable is not permitted.
- F. Armored cable is not permitted.
- G. Metal-clad cable is permitted only as follows:
 - 1. Where not otherwise restricted, may be used:
 - a. Where concealed above accessible ceilings for final connections from junction boxes to luminaires.
 - 1) Maximum Length: 6 feet.

2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductors for Grounding and Bonding: Also comply with Section 260526.
- H. Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where specifically permitted): Plenum rated, listed and labeled as suitable for use in return air plenums.
- I. Conductor Material:
 - 1. Provide copper conductors only. Aluminum conductors are not acceptable for this project. Conductor sizes indicated are based on copper.
 - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
 - 3. Tinned Copper Conductors: Comply with ASTM B33.
- J. Minimum Conductor Size: 12 AWG.
- K. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- L. Conductor Color Coding:
 - 1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
 - 2. Color Coding Method: Integrally colored insulation.

- a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
- 3. Color Code:
 - a. 480Y/277 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 4) Neutral/Grounded: Gray.
 - b. 208Y/120 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral/Grounded: White.
 - c. 240/120 V High-Leg Delta, 3 Phase, 4 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B (High-Leg): Orange.
 - 3) Phase C: Blue.
 - 4) Neutral/Grounded: White.
 - d. 240/120 V, 1 Phase, 3 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Neutral/Grounded: White.
 - e. Equipment Ground, All Systems: Green.
 - f. Isolated Ground, All Systems: Green with yellow stripe.
 - g. Travelers for 3-Way and 4-Way Switching: Pink.
 - h. For modifications or additions to existing wiring systems, comply with existing color code when existing code complies with NFPA 70 and is approved by the authority having jurisdiction.
 - i. For control circuits, comply with manufacturer's recommended color code.

2.03 SINGLE CONDUCTOR BUILDING WIRE

- A. Manufacturers:
 - 1. Copper Building Wire:
 - a. Cerro Wire LLC: www.cerrowire.com/#sle.
 - b. Encore Wire Corporation: www.encorewire.com/#sle.
 - c. General Cable Technologies Corporation: www.generalcable.com/#sle.
 - d. Service Wire Co: www.servicewire.com/#sle.
 - e. Southwire Company: www.southwire.com/#sle.
- B. Description: Single conductor insulated wire.
- C. Conductor Stranding:
 - 1. Feeders and Branch Circuits:
 - a. Size 10 AWG and Smaller: Solid.
 - b. Size 8 AWG and Larger: Stranded.
 - 2. Control Circuits: Stranded.
- D. Insulation Voltage Rating: 600 V.

E. Insulation:

1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.

2.04 METAL-CLAD CABLE

- A. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- B. Conductor Stranding:
 1. Size 10 AWG and Smaller: Solid.
 2. Size 8 AWG and Larger: Stranded.
- C. Insulation Voltage Rating: 600 V.
- D. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.
- E. Grounding: Full-size integral equipment grounding conductor.
- F. Armor: Steel, interlocked tape.

2.05 WIRING CONNECTORS

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

2.06 ACCESSORIES

- A. Electrical Tape:
 1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
 2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
 3. Rubber Splicing Electrical Tape: Ethylene Propylene Rubber (EPR) tape, complying with ASTM D4388; minimum thickness of 30 mil; suitable for continuous temperature environment up to 194 degrees F and short-term 266 degrees F overload service.
 4. Electrical Filler Tape: Rubber-based insulating moldable putty, minimum thickness of 125 mil; suitable for continuous temperature environment up to 176 degrees F.
 5. Moisture Sealing Electrical Tape: Insulating mastic compound laminated to flexible, all-weather vinyl backing; minimum thickness of 90 mil.
- B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.
 1. Manufacturers:
 - a. 3M: www.3m.com/#sle.
 - b. Burndy LLC: www.burndy.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
- C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.
 1. Manufacturers:
 - a. Burndy LLC: www.burndy.com/#sle.
 - b. Ideal Industries, Inc: www.idealindustries.com/#sle.

- c. Ilsco: www.ilsco.com/#sle.
- D. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.
 - 1. Manufacturers:
 - a. 3M: www.3m.com/#sle.
 - b. American Polywater Corporation: www.polywater.com/#sle.
 - c. Ideal Industries, Inc: www.idealindustries.com/#sle.
- E. Cable Ties: Material and tensile strength rating suitable for application.
 - 1. Manufacturers:
 - a. Burndy LLC: www.burndy.com/#sle.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that interior of building has been protected from weather.
- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as indicated.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.03 INSTALLATION

- A. Circuiting Requirements:
 - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
 - 2. When circuit destination is indicated without specific routing, determine exact routing required.
 - 3. Arrange circuiting to minimize splices.
 - 4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
 - 5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
 - 6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
 - 7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
 - 8. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among up to three single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
 - 9. Provide oversized neutral/grounded conductors where indicated and as specified below.
 - a. Provide 200 percent rated neutral for feeders fed from K-rated transformers.
 - b. Provide 200 percent rated neutral for feeders serving panelboards with 200 percent rated neutral bus.

- B. Install products in accordance with manufacturer's instructions.
 - C. Perform work in accordance with NECA 1 (general workmanship).
 - D. Install metal-clad cable (Type MC) in accordance with NECA 120.
 - E. Installation in Raceway:
 - 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
 - 2. Pull all conductors and cables together into raceway at same time.
 - 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 - 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
 - F. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
 - G. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
 - 1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
 - 2. Installation in Vertical Raceways: Provide supports where vertical rise exceeds permissible limits.
 - H. Terminate cables using suitable fittings.
 - 1. Metal-Clad Cable (Type MC):
 - a. Use listed fittings.
 - b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.
 - I. Install conductors with a minimum of 12 inches of slack at each outlet.
 - J. Where conductors are installed in enclosures for future termination by others, provide a minimum of 5 feet of slack.
 - K. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
 - L. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
 - M. Make wiring connections using specified wiring connectors.
 - 1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
 - 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
 - 3. Do not remove conductor strands to facilitate insertion into connector.
 - 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
 - 5. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
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- N. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
 - 1. Dry Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
 - a. For taped connections, first apply adequate amount of rubber splicing electrical tape or electrical filler tape, followed by outer covering of vinyl insulating electrical tape.
 - 2. Damp Locations: Use insulating covers specifically designed for the connectors, electrical tape, or heat shrink tubing.
 - a. For connections with insulating covers, apply outer covering of moisture sealing electrical tape.
 - b. For taped connections, follow same procedure as for dry locations but apply outer covering of moisture sealing electrical tape.
- O. Insulate ends of spare conductors using vinyl insulating electrical tape.
- P. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- Q. Identify conductors and cables in accordance with Section 260553.
- R. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- S. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.
- D. Correct deficiencies and replace damaged or defective conductors and cables.

END OF SECTION 260519

SECTION 260526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.

1.02 RELATED REQUIREMENTS

- A. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
- B. Section 260553 - Identification for Electrical Systems: Identification products and requirements.

1.03 REFERENCE STANDARDS

- A. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System; 2025.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- C. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings; 2022.
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.
- E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NFPA 99 - Health Care Facilities Code; 2024, with Errata.
- G. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify exact locations of underground metal water service pipe entrances to building.
 - 2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
 - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS**2.01 GROUNDING AND BONDING REQUIREMENTS**

- A. Existing Work: Where existing grounding and bonding system components are indicated to be reused, they may be reused only where they are free from corrosion, integrity and continuity are verified, and where acceptable to the authority having jurisdiction.
- B. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- C. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- D. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- E. Grounding System Resistance:
1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Architect. Precipitation within the previous 48 hours does not constitute normally dry conditions.
 2. Grounding Electrode System: Not greater than 5 ohms to ground, when tested according to IEEE 81 using "fall-of-potential" method.
 3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.
- F. Grounding Electrode System:
1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
 - a. Provide continuous grounding electrode conductors without splice or joint.
 - b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
 2. Metal Underground Water Pipe(s):
 - a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
 - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
 - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
 3. Concrete-Encased Electrode:
 - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
 4. Ground Rod Electrode(s):
 - a. Provide three electrodes in an equilateral triangle configuration unless otherwise indicated or required.
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- b. Space electrodes not less than 10 feet from each other and any other ground electrode.
 - c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
 - d. Provide ground access well for each electrode.
 - 5. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
 - 6. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in NFPA 70. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
 - a. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
 - b. Where ground bar location is not indicated, locate in accessible location as near as possible to service disconnect enclosure.
 - c. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.
 - 7. Ground Riser: Provide common grounding electrode conductor not less than 3/0 AWG for tap connections to multiple separately derived systems as permitted in NFPA 70.
- G. Service-Supplied System Grounding:
- 1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
 - 2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.
- H. Separately Derived System Grounding:
- 1. Separately derived systems include, but are not limited to:
 - a. Transformers (except autotransformers such as buck-boost transformers).
 - b. Uninterruptible power supplies (UPS), when configured as separately derived systems.
 - c. Generators, when neutral is switched in the transfer switch.
 - 2. Provide grounding electrode conductor to connect derived system grounded conductor to nearest effectively grounded metal building frame. Unless otherwise indicated, make connection at neutral (grounded) bus in source enclosure.
 - 3. Provide bonding jumper to connect derived system grounded conductor to nearest metal building frame and nearest metal water piping in the area served by the derived system, where not already used as a grounding electrode for the derived system. Make connection at same location as grounding electrode conductor connection.
 - 4. Where common grounding electrode conductor ground riser is used for tap connections to multiple separately derived systems, provide bonding jumper to connect the metal building frame and metal water piping in the area served by the derived system to the common grounding electrode conductor.
 - 5. Outdoor Source: Where the source of the separately derived system is located outside the building or structure supplied, provide connection to grounding electrode at source in accordance with NFPA 70.
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6. Provide system bonding jumper to connect system grounded conductor to equipment ground bus. Make connection at same location as grounding electrode conductor connection. Do not make any other connections between neutral (grounded) conductors and ground on load side of separately derived system disconnect.
 7. Where the source and first disconnecting means are in separate enclosures, provide supply-side bonding jumper between source and first disconnecting means.
- I. Bonding and Equipment Grounding:
1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
 2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
 3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
 4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
 5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
 6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
 7. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
 - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
 - b. Metal gas piping.
 8. Provide bonding for interior metal air ducts.
 9. Provide bonding for metal building frame.
 10. Provide bonding and equipment grounding for pools and fountains and associated equipment in accordance with NFPA 70.
 11. Provide redundant grounding and bonding for patient care areas of health care facilities in accordance with NFPA 70 and NFPA 99.

2.02 GROUNDING AND BONDING COMPONENTS

- A. General Requirements:
1. Provide products listed, classified, and labeled as suitable for the purpose intended.
 2. Provide products listed and labeled as complying with UL 467 where applicable.
- B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 260526:
1. Use insulated copper conductors unless otherwise indicated.
 - a. Exceptions:
 - 1) Use bare copper conductors where installed underground in direct contact with earth.
 - 2) Use bare copper conductors where directly encased in concrete (not in raceway).
- C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.

2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
 3. Unless otherwise indicated, use mechanical connectors or exothermic welded connections for accessible connections.
 - a. Exceptions:
 - 1) Use exothermic welded connections for connections to metal building frame.
 4. Manufacturers - Mechanical and Compression Connectors:
 - a. Advanced Lightning Technology (ALT): www.altfab.com/#sle.
 - b. Burndy LLC: www.burndy.com/#sle.
 - c. Harger Lightning & Grounding: www.harger.com/#sle.
 - d. Thomas & Betts Corporation: www.tnb.com/#sle.
 5. Manufacturers - Exothermic Welded Connections:
 - a. Burndy LLC: www.burndy.com/#sle.
 - b. Cadweld, a brand of Erico International Corporation: www.erico.com/#sle.
 - c. thermOweld, subsidiary of Continental Industries; division of Burndy LLC: www.thermoweld.com/#sle.
- D. Ground Bars:
1. Description: Copper rectangular ground bars with mounting brackets and insulators.
 2. Size: As indicated.
 3. Holes for Connections: 9/32-inch holes spaced 1-1/8" apart..
 4. Manufacturers:
 - a. Advanced Lightning Technology (ALT): www.altfab.com/#sle.
 - b. Erico International Corporation: www.erico.com/#sle.
 - c. Harger Lightning & Grounding: www.harger.com/#sle.
 - d. thermOweld, subsidiary of Continental Industries; division of Burndy LLC: www.thermoweld.com/#sle.
- E. Ground Rod Electrodes:
1. Comply with NEMA GR 1.
 2. Material: Copper-bonded (copper-clad) steel.
 3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.
 4. Manufacturers:
 - a. Advanced Lightning Technology (ALT): www.altfab.com/#sle.
 - b. Erico International Corporation: www.erico.com/#sle.
 - c. Galvan Industries, Inc: www.galvanelectrical.com/#sle.
 - d. Harger Lightning & Grounding: www.harger.com/#sle.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).

- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70.
 - 1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
- D. Make grounding and bonding connections using specified connectors.
 - 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
 - 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
 - 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
 - 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 - 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- E. Identify grounding and bonding system components in accordance with Section 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.13.
- D. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- E. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

END OF SECTION 260526

**SECTION 260529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

PART 1 GENERAL

1.01 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 260533.13 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.
- C. Section 260533.16 - Boxes for Electrical Systems: Additional support and attachment requirements for boxes.
- D. Section 265100 - Interior Lighting: Additional support and attachment requirements for interior luminaires.

1.02 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2024.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2016a.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2019.
- D. MFMA-4 - Metal Framing Standards Publication; 2004.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported at 5 times the applied force. Include consideration for vibration, equipment operation, and shock loads where applicable.
 - 4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
 - 5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.

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- d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
 - B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
 - 1. Conduit Straps: One-hole or two-hole type; steel.
 - 2. Conduit Clamps: Bolted type unless otherwise indicated.
 - 3. Manufacturers:
 - a. Cooper Crouse-Hinds, a division of Eaton Corporation: www.cooperindustries.com/#sle.
 - b. Erico International Corporation: www.erico.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
 - C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.
 - 1. Manufacturers:
 - a. Cooper Crouse-Hinds, a division of Eaton Corporation: www.cooperindustries.com/#sle.
 - b. Erico International Corporation: www.erico.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
 - D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 - 1. Comply with MFMA-4.
 - 2. Manufacturers:
 - a. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com/#sle.
 - b. Thomas & Betts Corporation: www.tnb.com/#sle.
 - c. Unistrut, a brand of Atkore International Inc; _____: www.unistrut.com/#sle.
 - d. Substitutions: See Section 016000 - Product Requirements.
 - e. Source Limitations: Furnish channels (struts) and associated fittings, accessories, and hardware produced by a single manufacturer.
 - E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
 - 1. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Busway Supports: 1/2 inch diameter.
 - c. Single Conduit up to 1 inch (27 mm) trade size: 1/4 inch diameter.
 - d. Single Conduit larger than 1 inch (27 mm) trade size: 3/8 inch diameter.
 - e. Trapeze Support for Multiple Conduits: 3/8 inch diameter.
 - f. Outlet Boxes: 1/4 inch diameter.
 - g. Luminaires: 1/4 inch diameter.
 - F. Anchors and Fasteners:
 - 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
 - 2. Concrete: Use preset concrete inserts or expansion anchors.
 - 3. Solid or Grout-Filled Masonry: Use expansion anchors.
 - 4. Hollow Masonry: Use toggle bolts.
 - 5. Hollow Stud Walls: Use toggle bolts.
 - 6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
 - 7. Sheet Metal: Use sheet metal screws.
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8. Plastic and lead anchors are not permitted.
9. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 4 inch high concrete pad constructed in accordance with Section 033000.
 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Conduit Support and Attachment: Also comply with Section 260533.13.
- I. Box Support and Attachment: Also comply with Section 260533.16.
- J. Interior Luminaire Support and Attachment: Also comply with Section 265100.
- K. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- L. Secure fasteners according to manufacturer's recommended torque settings.
- M. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.

- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION 260529

**SECTION 260533.13
CONDUIT FOR ELECTRICAL SYSTEMS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Flexible metal conduit (FMC).
- C. Liquidtight flexible metal conduit (LFMC).
- D. Electrical metallic tubing (EMT).
- E. Rigid polyvinyl chloride (PVC) conduit.
- F. Liquidtight flexible nonmetallic conduit (LFNC).
- G. Conduit fittings.
- H. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete encasement of conduits.
- B. Section 078400 - PENETRATION FIRESTOPPING.
- C. Section 260526 - Grounding and Bonding for Electrical Systems.
 - 1. Includes additional requirements for fittings for grounding and bonding.
- D. Section 260529 - Hangers and Supports for Electrical Systems.
- E. Section 260548 - Vibration and Seismic Controls for Electrical Systems.
- F. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- G. Section 262100 - Low-Voltage Electrical Service Entrance: Additional requirements for electrical service conduits.
- H. Section 312316.13 - Trenching: Excavating, bedding, and backfilling.

1.03 REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2020.
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S); 2020.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- D. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); 2020.
- E. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC); 2025.
- F. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.
- G. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; 2020.
- H. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; 2021.
- I. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. UL 1 - Flexible Metal Conduit; Current Edition, Including All Revisions.
- K. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.

- L. UL 360 - Liquid-Tight Flexible Metal Conduit; Current Edition, Including All Revisions.
- M. UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.
- N. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.
- O. UL 797 - Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.
- P. UL 1203 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.
- Q. UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
 - 4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.
- C. Shop Drawings:
 - 1. Include proposed locations of roof penetrations and proposed methods for sealing.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.01 CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.

- C. Underground:
 - 1. Under Slab on Grade: Use rigid PVC conduit.
 - 2. Exterior, Direct-Buried: Use rigid PVC conduit.
 - 3. Exterior, Embedded Within Concrete: Use galvanized steel rigid metal conduit or rigid PVC conduit.
 - 4. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.
 - 5. Where rigid polyvinyl (PVC) conduit larger than 2 inch (53 mm) trade size is provided, use galvanized steel rigid metal conduit elbows for bends.
- D. Embedded Within Concrete:
 - 1. Within Slab on Grade: Not permitted.
 - 2. Within Slab Above Ground: Not permitted.
- E. Concealed Within Hollow Stud Walls: Use electrical metallic tubing (EMT).
- F. Concealed Above Accessible Ceilings: Use electrical metallic tubing (EMT).
- G. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.
- H. Exposed, Interior, Not Subject to Physical Damage: Use electrical metallic tubing (EMT).
- I. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit.
- J. Exposed, Exterior: Use galvanized steel rigid metal conduit.
- K. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit.
- L. Hazardous (Classified) Locations: Use galvanized steel rigid metal conduit.
- M. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
 - 1. Maximum Length: 6 feet.
- N. Connections to Vibrating Equipment:
 - 1. Dry Locations: Use flexible metal conduit.
 - 2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
 - 3. Maximum Length: 6 feet unless otherwise indicated.
 - 4. Vibrating equipment includes, but is not limited to:
 - a. Transformers.
 - b. Motors.
- O. Fished in Existing Non-Accessible Walls, Where Necessary: Use flexible metal conduit.

2.02 CONDUIT REQUIREMENTS

- A. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from corrosion, and integrity is verified by pulling a mandrel through them.
- B. Electrical Service Conduits: Also comply with Section 262100.
- C. Fittings for Grounding and Bonding: Also comply with Section 260526.
- D. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.
- E. Provide products listed, classified, and labeled as suitable for the purpose intended.
- F. Minimum Conduit Size, Unless Otherwise Indicated:
 - 1. Branch Circuits: 3/4 inch (21 mm) trade size.
 - 2. Branch Circuit Homeruns: 3/4 inch (21 mm) trade size.

3. Control Circuits: 1/2 inch (16 mm) trade size.
 4. Flexible Connections to Luminaires: 1/2 inch (16 mm) trade size.
 5. Underground, Interior: 3/4 inch (21 mm) trade size.
 6. Underground, Exterior: 1 inch (27 mm) trade size.
- G. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Manufacturers:
1. Allied Tube & Conduit, a division of Atkore International: www.alliedeg.com/#sle.
 2. Nucor Tubular Products: www.nucortubular.com/#sle.
 3. Western Tube, a division of Zekelman Industries: www.westerntube.com/#sle.
 4. Wheatland Tube, a division of Zekelman Industries: www.wheatland.com/#sle.
 5. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- C. Fittings:
1. Manufacturers:
 - a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
 - b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
 - d. Substitutions: See Section 016000 - Product Requirements.
 2. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 3. Hazardous (Classified) Locations: Use fittings listed and labeled as complying with UL 1203 for the classification of the installed location.
 4. Material: Use steel.
 5. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.04 FLEXIBLE METAL CONDUIT (FMC)

- A. Manufacturers:
1. AFC Cable Systems, Inc: www.afcweb.com/#sle.
 2. Electri-Flex Company: www.electriflex.com/#sle.
 3. International Metal Hose: www.metalhose.com/#sle.
 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type FMC standard wall steel flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.
- C. Fittings:
1. Manufacturers:
 - a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
 - b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 3. Material: Use steel or malleable iron.

2.05 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. Manufacturers:
 - 1. AFC Cable Systems, Inc: www.afcweb.com/#sle.
 - 2. Electri-Flex Company: www.electriflex.com/#sle.
 - 3. International Metal Hose: www.metalhose.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.
- C. Fittings:
 - 1. Manufacturers:
 - a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
 - b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
 - d. Substitutions: See Section 016000 - Product Requirements.
 - 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 3. Material: Use steel or malleable iron.

2.06 ELECTRICAL METALLIC TUBING (EMT)

- A. Manufacturers:
 - 1. Allied Tube & Conduit, a division of Atkore International: www.alliedeg.com/#sle.
 - 2. Nucor Tubular Products: www.nucortubular/#sle.
 - 3. Western Tube, a division of Zekelman Industries: www.westerntube.com/#sle.
 - 4. Wheatland Tube, a division of Zekelman Industries: www.wheatland.com/#sle.
 - 5. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- C. Fittings:
 - 1. Manufacturers:
 - a. Bridgeport Fittings Inc: www.bptfittings.com/#sle.
 - b. O-Z/Gedney, a brand of Emerson Electric Co: www.emerson.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
 - d. Substitutions: See Section 016000 - Product Requirements.
 - 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 3. Material: Use steel.
 - 4. Connectors and Couplings: Use set-screw type.
 - a. Do not use indenter type connectors and couplings.
 - 5. Damp or Wet Locations (where permitted): Use fittings listed for use in wet locations.
 - 6. Embedded Within Concrete (where permitted): Use fittings listed as concrete-tight. Fittings that require taping to be concrete-tight are acceptable.

2.07 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

- A. Manufacturers:
 - 1. Cantex Inc: www.cantexinc.com/#sle.
 - 2. Carlon, a brand of Thomas & Betts Corporation: www.carlon.com/#sle.
 - 3. JM Eagle: www.jmeagle.com/#sle.

- 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage; rated for use with conductors rated 90 degrees C.
- C. Fittings:
 - 1. Manufacturer: Same as manufacturer of conduit to be connected.
 - 2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.08 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)

- A. Manufacturers:
 - 1. AFC Cable Systems, Inc: www.afcweb.com/#sle.
 - 2. Electri-Flex Company: www.electriflex.com/#sle.
 - 3. International Metal Hose: www.metalhose.com/#sle.
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Description: NFPA 70, Type LFNC liquidtight flexible nonmetallic conduit listed and labeled as complying with UL 1660.
- C. Fittings:
 - 1. Manufacturer: Same as manufacturer of conduit to be connected.
 - 2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B; suitable for the type of conduit to be connected.

2.09 ACCESSORIES

- A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil.
- B. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.
- C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- D. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.
- E. Sealing Compound for Sealing Fittings: Listed for use with the particular fittings to be installed.
- F. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.
- G. Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for conduits and roofing system to be installed; designed to accommodate existing penetrations where applicable.
- H. Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for conduits and facade materials to be installed.
- I. Duct Bank Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for concrete encasement in open trench installation; suitable for the conduit/duct arrangement to be installed.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive conduits.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
 - B. Perform work in accordance with NECA 1 (general workmanship).
 - C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
 - D. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
 - E. Install liquidtight flexible nonmetallic conduit (LFNC) in accordance with NECA 111.
 - F. Conduit Routing:
 - 1. Unless dimensioned, conduit routing indicated is diagrammatic.
 - 2. When conduit destination is indicated without specific routing, determine exact routing required.
 - 3. Conceal all conduits unless specifically indicated to be exposed.
 - 4. Conduits in the following areas may be exposed, unless otherwise indicated:
 - a. Electrical rooms.
 - b. Mechanical equipment rooms.
 - c. Within joists in areas with no ceiling.
 - 5. Unless otherwise approved or indicated on associated documents, do not route conduits exposed:
 - a. Across floors.
 - b. Across roofs.
 - c. Across top of parapet walls.
 - d. Across building exterior surfaces.
 - 6. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
 - 7. Conduits run within slab on deck applications are NOT acceptable.
 - 8. Arrange conduit to maintain adequate headroom, clearances, and access.
 - 9. Arrange conduit to provide no more than the equivalent of three 90 degree bends between pull points.
 - 10. Arrange conduit to provide no more than 150 feet between pull points.
 - 11. Route conduits above water and drain piping where possible.
 - 12. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
 - 13. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
 - a. Heaters.
 - b. Hot water piping.
 - c. Flues.
 - G. Conduit Support:
 - 1. Secure and support conduits in accordance with NFPA 70 and Section 260529 using suitable supports and methods approved by the authority having jurisdiction.
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2. Provide required vibration isolation and/or seismic controls in accordance with Section 260548.
 3. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
 4. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
 5. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
 6. Use conduit clamp to support single conduit from beam clamp or threaded rod.
 7. Use trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits.
 8. Use non-penetrating rooftop supports to support conduits routed across rooftops (only where approved).
 9. Use of spring steel conduit clips for support of conduits is not permitted.
 10. Use of wire for support of conduits is not permitted.
 11. Where conduit support intervals specified in NFPA 70 and NECA standards differ, comply with the most stringent requirements.
- H. Connections and Terminations:
1. Use approved conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
 2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
 3. Use suitable adapters where required to transition from one type of conduit to another.
 4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
 5. Terminate threaded conduits in boxes and enclosures using threaded hubs for dry locations and raintight hubs for wet locations.
 6. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
 7. Secure joints and connections to provide maximum mechanical strength and electrical continuity.
- I. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
 2. Make penetrations perpendicular to surfaces unless otherwise indicated.
 3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
 4. Conceal bends for conduit risers emerging above ground.
 5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
 6. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
 7. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
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8. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- J. Underground Installation:
 1. Provide trenching and backfilling in accordance with Section 312316.13.
 2. Minimum Cover, Unless Otherwise Indicated or Required:
 - a. Underground, Exterior: 24 inches.
 - b. Under Slab on Grade: 12 inches to bottom of slab.
 3. Provide underground warning tape in accordance with Section 260553 along entire conduit length for service entrance where not concrete-encased.
- K. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 033000 with minimum concrete cover of 3 inches on all sides unless otherwise indicated.
- L. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
 1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
 2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
 3. Where conduits are subject to earth movement by settlement or frost.
- M. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
 1. Where conduits pass from outdoors into conditioned interior spaces.
 2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
- N. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.
- O. Provide grounding and bonding in accordance with Section 260526.
- P. Identify conduits in accordance with Section 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Correct deficiencies and replace damaged or defective conduits.

3.04 CLEANING

- A. Clean interior of conduits to remove moisture and foreign matter.

3.05 PROTECTION

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION 260533.13

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**SECTION 260533.16
BOXES FOR ELECTRICAL SYSTEMS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Underground boxes/enclosures.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 083100 - ACCESS DOORS AND PANELS: Panels for maintaining access to concealed boxes.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260533.13 - Conduit for Electrical Systems:
 - 1. Conduit bodies and other fittings.
 - 2. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.
- E. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 262726 - Wiring Devices:
 - 1. Wall plates.
 - 2. Additional requirements for locating boxes for wiring devices.
- G. Section 271000 - Structured Cabling: Additional requirements for communications systems outlet boxes.

1.03 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2016.
- C. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- D. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.
- E. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; 2013 (Reaffirmed 2020).
- F. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports; 2013 (Reaffirmed 2020).
- G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. SCTE 77 - Specifications for Underground Enclosure Integrity; 2023.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.
- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

- K. UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.
- L. UL 514A - Metallic Outlet Boxes; Current Edition, Including All Revisions.
- M. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
 - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
 - 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
 - 6. Coordinate the work with other trades to preserve insulation integrity.
 - 7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
 - 8. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.
- C. Samples:
 - 1. Floor Boxes: Provide one sample(s) of each floor box proposed for substitution upon request.
- D. Project Record Documents: Record actual locations for pull boxes, cabinets and enclosures, floor boxes, and underground boxes/enclosures.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.
 - 2. Keys for Lockable Enclosures: Two of each different key.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.01 BOXES

- A. General Requirements:

-
1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
 3. Provide products listed, classified, and labeled as suitable for the purpose intended.
 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
 2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
 3. Use cast iron boxes or cast aluminum boxes where exposed galvanized steel rigid metal conduit is used.
 4. Use nonmetallic boxes where exposed rigid PVC conduit is used.
 5. Use suitable concrete type boxes where flush-mounted in concrete.
 6. Use suitable masonry type boxes where flush-mounted in masonry walls.
 7. Use raised covers suitable for the type of wall construction and device configuration where required.
 8. Use shallow boxes where required by the type of wall construction.
 9. Do not use "through-wall" boxes designed for access from both sides of wall.
 10. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
 11. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
 12. Nonmetallic Boxes: Comply with NEMA OS 2, and list and label as complying with UL 514C.
 13. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
 14. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
 15. Minimum Box Size, Unless Otherwise Indicated:
 - a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch by 2-1/8 inches by 2-1/8 inches deep unless otherwise noted.
 - b. Communications Systems Outlets: 4 inch square by 2-1/8 inch (100 by 54 mm) trade size.
 - c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.
 16. Wall Plates: Comply with Section 262726.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
1. Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
 2. NEMA EN 10250 Environment Type, Unless Otherwise Indicated:
 - a. Indoor Clean, Dry Locations: Type 1, painted steel.
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- b. Outdoor Locations: Type 3R, painted steel.
- 3. Junction and Pull Boxes Larger Than 100 cubic inches:
 - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
 - b. Boxes 6 square feet and Larger: Provide hinged-cover enclosures.
- 4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
 - a. Provide lockable hinged covers, all locks keyed alike unless otherwise indicated.
- 5. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.
- D. Underground Boxes/Enclosures:
 - 1. Description: In-ground, open bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.
 - 2. Size: As indicated on drawings.
 - 3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 12 inches.
 - 4. Provide logo on cover to indicate type of service.
 - 5. Applications:
 - a. Sidewalks and Landscaped Areas Subject Only to Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 8 load rating.
 - b. Parking Lots, in Areas Subject Only To Occasional Nondeliberate Vehicular Traffic: Use polymer concrete enclosures, with minimum SCTE 77 Tier 15 load rating.
 - 6. Polymer Concrete Underground Boxes/Enclosures: Comply with SCTE 77.
 - a. Manufacturers:
 - 1) MacLean Highline; _____: www.macleanhighline.com/#sle.
 - 2) Oldcastle Precast, Inc; _____: www.oldcastleprecast.com/#sle.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive boxes.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide separate boxes for emergency power and normal power systems.
- E. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- F. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- G. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- H. Box Locations:

1. Locate boxes to be accessible. Provide access panels in accordance with Section 083100 as required where approved by the Architect.
 2. Unless dimensioned, box locations indicated are approximate.
 3. Locate boxes as required for devices installed under other sections or by others.
 - a. Switches, Receptacles, and Other Wiring Devices: Comply with Section 262726.
 - b. Communications Systems Outlets: Comply with Section 271000.
 4. Locate boxes so that wall plates do not span different building finishes.
 5. Locate boxes so that wall plates do not cross masonry joints.
 6. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
 7. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
 - a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
 8. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 260533.13.
- I. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 260529 using suitable supports and methods approved by the authority having jurisdiction.
 2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
 3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
- J. Install boxes plumb and level.
- K. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
 2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
 3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- L. Install boxes as required to preserve insulation integrity.
- M. Nonmetallic Floor Boxes: Cut box flush with finished floor after concrete pour.
- N. Underground Boxes/Enclosures:
1. Install enclosure on gravel base, minimum 6 inches deep.
 2. Flush-mount enclosures located in concrete or paved areas.
 3. Mount enclosures located in landscaped areas with top at 1 inch above finished grade.
 4. Provide cast-in-place concrete collar constructed in accordance with Section 033000, minimum 10 inches wide by 12 inches deep, around enclosures that are not located in concrete areas.
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- 5. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.
- O. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- P. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- Q. Close unused box openings.
- R. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- S. Provide grounding and bonding in accordance with Section 260526.
- T. Identify boxes in accordance with Section 260553.

3.03 CLEANING

- A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

3.04 PROTECTION

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

END OF SECTION 260533.16

**SECTION 260553
IDENTIFICATION FOR ELECTRICAL SYSTEMS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Wire and cable markers.
- D. Voltage markers.
- E. Underground warning tape.
- F. Floor marking tape.
- G. Warning signs and labels.

1.02 RELATED REQUIREMENTS

- A. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.
- B. Section 262726 - Wiring Devices - Lutron: Device and wallplate finishes; factory pre-marked wallplates.
- C. Section 271000 - Structured Cabling: Identification for communications cabling and devices.

1.03 REFERENCE STANDARDS

- A. ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs; 2023.
- B. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels; 2023.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL 969 - Marking and Labeling Systems; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.
- B. Sequencing:
 - 1. Do not conceal items to be identified, in locations such as above suspended ceilings, until identification products have been installed.
 - 2. Do not install identification products until final surface finishes and painting are complete.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.
- C. Shop Drawings: Provide schedule of items to be identified indicating proposed designations, materials, legends, and formats.
- D. Samples:
 - 1. Identification Nameplates: One of each type and color specified.

2. Warning Signs and Labels: One of each type and legend specified.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Adhesive-attached labeling materials, including label stocks, laminating adhesive, and inks used by label printers, shall comply with UL 969.

PART 2 PRODUCTS

2.01 IDENTIFICATION REQUIREMENTS

- A. Identification for Equipment:
 1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
 - a. Panelboards:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Identify main overcurrent protective device. Use identification label for panelboards with a door. For power distribution panelboards without a door, use identification nameplate.
 - 5) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces.
 - 6) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.
 - b. Enclosed switches, circuit breakers, and motor controllers:
 - 1) Identify voltage and phase.
 - 2) Identify power source and circuit number. Include location when not within sight of equipment.
 - 3) Identify load(s) served. Include location when not within sight of equipment.
 - c. Electricity Meters:
 - 1) Identify load(s) metered.
 2. Use voltage marker to identify highest voltage present for each piece of electrical equipment.
 3. Use identification nameplate to identify equipment utilizing series ratings, where permitted, in accordance with NFPA 70.
 4. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.
 5. Use identification label or handwritten text using indelible marker on inside of door at each fused switch to identify required NEMA fuse class and size.
 6. Use identification label or handwritten text using indelible marker on inside of door at each motor controller to identify nameplate horsepower, full load amperes, code letter, service factor, voltage, and phase of motor(s) controlled.
 7. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".
 8. Use field-painted floor markings, floor marking tape, or warning labels to identify required equipment working clearances where indicated or where required by the authority having jurisdiction.

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- a. Field-Painted Floor Markings: Alternating black and white stripes, 3 inches wide, painted in accordance with Section 099123 and 099113.
 - B. Identification for Conductors and Cables:
 - 1. Color Coding for Power Conductors 600 V and Less: Comply with Section 260519.
 - 2. Identification for Communications Conductors and Cables: Comply with Section 271000.
 - 3. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.
 - 4. Use wire and cable markers to identify circuit number or other designation indicated for power, control, and instrumentation conductors and cables at the following locations:
 - a. At each source and load connection.
 - b. Within boxes when more than one circuit is present.
 - c. Within equipment enclosures when conductors and cables enter or leave the enclosure.
 - d. In cable tray, at maximum intervals of 20 feet.
 - 5. Use wire and cable markers to identify connected grounding electrode system components for grounding electrode conductors.
 - 6. Use underground warning tape to identify direct buried cables.
 - C. Identification for Raceways:
 - 1. Use voltage markers to identify highest voltage present for accessible conduits 3" high at maximum intervals of 20 feet.
 - 2. Use voltage markers or color-coded bands to identify systems other than normal power system for accessible conduits at maximum intervals of 20 feet.
 - a. Color-Coded Bands: Use field-painting or vinyl color coding electrical tape to mark bands 3 inches wide.
 - 1) Color Code:
 - (a) Emergency Power System: Red.
 - (b) Fire Alarm System: Red.
 - 2) Field-Painting: Comply with Section 099123 and 099113.
 - 3) Vinyl Color Coding Electrical Tape: Comply with Section 260519.
 - 3. Use identification labels to identify circuits enclosed for accessible conduits at wall penetrations, at floor penetrations, at roof penetrations, and at equipment terminations when source is not within sight.
 - 4. Use identification labels to identify spare conduits at each end. Identify purpose and termination location.
 - 5. Use underground warning tape to identify underground raceways.
 - 6. Use voltage markers to identify highest voltage present for wireways at maximum intervals of 20 feet.
 - D. Identification for Boxes:
 - 1. Use voltage markers to identify highest voltage present.
 - 2. Use voltage markers or color coded boxes to identify systems other than normal power system.
 - a. Color-Coded Boxes: Field-painted in accordance with Section 099123 and 099113 per the same color code used for raceways.
 - 1) Emergency Power System: Red.
 - b. For exposed boxes in public areas, do not color code.
-

3. Use identification labels to identify circuits enclosed.
 - a. For exposed boxes in public areas, use only identification labels.
 4. Use warning labels to identify electrical hazards for boxes containing exposed live parts or exposed conductors operating at over 600 V nominal with the word message "DANGER; HIGH VOLTAGE; KEEP OUT".
- E. Identification for Devices:
1. Identification for Communications Devices: Comply with Section 271000.
 2. Wiring Device and Wallplate Finishes: Comply with Section 262726.
 3. Factory Pre-Marked Wallplates: Comply with Section 262726.
 4. Use identification label to identify fire alarm system devices.
 - a. For devices concealed above suspended ceilings, provide additional identification on ceiling tile below device location.
 5. Use identification label or engraved wallplate to identify serving branch circuit for all receptacles.
- F. Identification for Luminaires:
1. Use permanent red dot on luminaire frame to identify luminaires connected to emergency power system.
- G. Identification for Photovoltaic Systems: Comply with Section 263100

2.02 IDENTIFICATION NAMEPLATES AND LABELS

- A. Identification Nameplates:
1. Materials:
 - a. Indoor Clean, Dry Locations: Use plastic nameplates.
 - b. Outdoor Locations: Use plastic, stainless steel, or aluminum nameplates suitable for exterior use.
 2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
 - a. Exception: Provide minimum thickness of 1/8 inch when any dimension is greater than 4 inches.
 3. Stainless Steel Nameplates: Minimum thickness of 1/32 inch; engraved or laser-etched text.
 4. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch; engraved or laser-etched text.
 5. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.
- B. Identification Labels:
1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
 - a. Use only for indoor locations.
 2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
- C. Format for Equipment Identification:
1. Minimum Size: 1 inch by 2.5 inches.
 2. Legend:
 - a. System designation where applicable:
 - 1) Emergency Power System: Identify with text "EMERGENCY".
 - 2) Fire Alarm System: Identify with text "FIRE ALARM".

- b. Equipment designation or other approved description.
 - 3. Text: All capitalized unless otherwise indicated.
 - 4. Minimum Text Height:
 - a. System Designation: 1 inch.
 - b. Equipment Designation: 1/2 inch.
 - c. Other Information: 1/4 inch.
 - d. Exception: Provide minimum text height of 1 inch for equipment located more than 10 feet above floor or working platform.
 - 5. Color:
 - a. Normal Power System: White text on black background.
 - b. Emergency Power System: White text on red background.
- D. Format for General Information and Operating Instructions:
 - 1. Minimum Size: 1 inch by 2.5 inches.
 - 2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.
 - 3. Text: All capitalized unless otherwise indicated.
 - 4. Minimum Text Height: 1/4 inch.
 - 5. Color: Black text on white background unless otherwise indicated.
- E. Format for Receptacle Identification:
 - 1. Minimum Size: 3/8 inch by 1.5 inches.
 - 2. Legend: Power source and circuit number or other designation indicated.
 - 3. Text: All capitalized unless otherwise indicated.
 - 4. Minimum Text Height: 3/16 inch.
 - 5. Color: Black text on white background.
- F. Format for Fire Alarm Device Identification:
 - 1. Minimum Size: 3/8 inch by 1.5 inches.
 - 2. Legend: Designation indicated and device zone or address.
 - 3. Text: All capitalized unless otherwise indicated.
 - 4. Minimum Text Height: 3/16 inch.
 - 5. Color: Red text on white background.

2.03 WIRE AND CABLE MARKERS

- A. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.
- B. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.
- C. Legend: Power source and circuit number or other designation indicated.
- D. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.
 - 1. Do not use handwritten text.
- E. Minimum Text Height: 1/8 inch.
- F. Color: Black text on white background unless otherwise indicated.

2.04 VOLTAGE MARKERS

- A. Markers for Conduits: Use factory pre-printed self-adhesive vinyl, self-adhesive vinyl cloth, or vinyl snap-around type markers.

- B. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.
- C. Minimum Size:
 - 1. Markers for Equipment: 1 1/8 by 4 1/2 inches.
 - 2. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.
 - 3. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
 - 4. Markers for Junction Boxes: 1/2 by 2 1/4 inches.
- D. Legend:
 - 1. Markers for Voltage Identification: Highest voltage present.
- E. Color: Black text on orange background unless otherwise indicated.

2.05 WARNING SIGNS AND LABELS

- A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B. Warning Signs:
 - 1. Materials:
 - a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.
 - b. Outdoor Locations: Use factory pre-printed rigid aluminum signs.
 - 2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.
 - 3. Minimum Size: 7 by 10 inches unless otherwise indicated.
- C. Warning Labels:
 - 1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
 - a. Do not use labels designed to be completed using handwritten text.
 - 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
 - 3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.01 PREPARATION

- A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
 - 1. Surface-Mounted Equipment: Enclosure front.
 - 2. Flush-Mounted Equipment: Enclosure front.
 - 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
 - 4. Elevated Equipment: Legible from the floor or working platform.
 - 5. Branch Devices: Adjacent to device.
 - 6. Interior Components: Legible from the point of access.
 - 7. Conduits: Legible from the floor.
 - 8. Boxes: Outside face of cover.

- 9. Conductors and Cables: Legible from the point of access.
- 10. Devices: Outside face of cover.
- C. Install identification products centered, level, and parallel with lines of item being identified.
- D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.
- E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.
- F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.
- G. Secure rigid signs using stainless steel screws.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION 260553

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**SECTION 260923
LIGHTING CONTROL DEVICES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Occupancy sensors.
- B. Daylighting controls.
- C. Room Controllers
- D. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 260529 - Hangers and Supports for Electrical Systems
- B. Section 260533.16 - Boxes for Electrical Systems.
- C. Section 262726 - Wiring Devices: Devices for manual control of lighting, including wall switches, wall dimmers, and fan speed controllers.

1.03 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2016.
- C. NEMA IA 10039 - Control Circuit and Pilot Devices; 2025.
- D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
- C. Shop Drawings:
 - 1. Occupancy Sensors: Provide lighting plan indicating location, model number, and orientation of each occupancy sensor and associated system component.
- D. Field Quality Control Reports.
- E. Operation and Maintenance Data: Include detailed information on device programming and setup.
- F. Project Record Documents: Record actual installed locations and settings for lighting control devices.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.06 DELIVERY, STORAGE, AND PROTECTION

- A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

1.07 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.

- B. Provide five year manufacturer warranty for utility grade locking receptacle-mounted outdoor photo controls.

PART 2 PRODUCTS

2.01 LIGHTING CONTROL DEVICES - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system.
- C. All Ceiling Mounted Occupancy Sensors. Note: there are (2) versions of occupancy sensors; the first are low voltage which shall be powered thru/connected to a Room Controller, as noted/shown on E000 and E800. The second are standalone [LV denotation] that are powered thru/connected to a universal power pack.
- D. Substitutions:
 - 1. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date and must be made available to all bidders. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
 - 2. Any substitutions provided by the contractor shall be reviewed at the contractor's expense by the electrical engineer at rate.
 - 3. By using pre-approved substitutions, the contractor accepts responsibility and associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power and control wiring) with deviations from the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.02 OCCUPANCY SENSORS

- A. Manufacturers:
 - 1. Crestron Electronics, Inc: www.crestron.com/#sle
 - 2. Sensorworx: www.sensorworx.com/#sle
 - 3. Hubbell Incorporated: www.hubbell.com/#sle.
 - 4. Lutron Electronics Company, Inc: www.lutron.com/#sle.
 - 5. Sensor Switch Inc; _____: www.sensorswitch.com/#sle.
 - 6. WattStopper; _____: www.wattstopper.com/#sle.
 - 7. All Occupancy Sensors:
 - a. Description: Factory-assembled commercial specification grade devices for indoor use capable of sensing both major motion, such as walking, and minor motion, such as small desktop level movements, according to published coverage areas, for automatic control of load indicated.
 - b. Sensor Technology:
 - 1) Passive Infrared/Ultrasonic Dual Technology Occupancy Sensors: Designed to detect occupancy using a combination of both passive infrared and ultrasonic technologies.
 - c. Provide LED to visually indicate motion detection with separate color LEDs for each sensor type in dual technology units.
 - d. Operation: Unless otherwise indicated, occupancy sensor to turn load on when occupant presence is detected and to turn load off when no occupant presence is detected during an adjustable turn-off delay time interval.
 - e. Turn-Off Delay: Field adjustable, with time delay settings up to 30 minutes.

8. Wall Switch Occupancy Sensors:
 - a. Passive Infrared/Ultrasonic Dual Technology Wall Switch Occupancy Sensors:
Capable of detecting motion within an area of 900 square feet.
9. Ceiling Mounted Occupancy Sensors:
 - a. All Ceiling Mounted Occupancy Sensors. Note: there are (2) versions of occupancy sensors; the first are low voltage shall be powered thru/connected to a Room Controller, as noted/shown on E000 and E800. The second are standalone [no denotation] that are powered thru/connected to wired thru a universal power pack.
 - 1) Description: Low profile occupancy sensors designed for ceiling installation.
 - 2) Unless otherwise indicated or required to control the load indicated on drawings, provide low voltage units, for use with separate compatible accessory power packs.
 - 3) Provide field selectable setting for disabling LED motion detector visual indicator.
 - 4) Occupancy sensor to be field selectable as either manual-on/automatic-off or automatic on/off.
 - 5) Finish: White unless otherwise indicated.
 - b. Passive Infrared/Ultrasonic Dual Technology Ceiling Mounted Occupancy Sensors:
 - 1) Standard Range Sensors: Capable of detecting motion within an area of 450 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
10. Power Packs for Low Voltage Occupancy Sensors:
 - a. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage occupancy sensors for switching of line voltage loads.
 - b. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
 - c. Input Supply Voltage: Dual rated for 120/277 V ac.

2.03 DAYLIGHTING CONTROLS

- A. Manufacturers:
 1. Crestron Electronics, Inc: www.crestron.com/#sle
 2. Sensorworx: www.sensorworx.com/#sle
 3. Hubbell Control Solutions: www.hubbell.com/hubbellcontrolsolutions/en/#sle. Hubbell Control Solutions: www.hubbell.com/hubbellcontrolsolutions/en/#sle. Hubbell Control Solutions: www.hubbell.com/hubbellcontrolsolutions/en/#sle.
 4. Lutron Electronics Company, Inc: www.lutron.com/#sle.
 5. Sensor Switch Inc: www.sensorswitch.com/#sle.
 6. WattStopper: www.wattstopper.com/#sle.
 7. Substitutions: See Section 016000 - Product Requirements.
 8. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.
- B. System Description: Control system consisting of photo sensors and compatible control modules and power packs, contactors, or relays as required for automatic control of load indicated according to available natural light; capable of integrating with occupancy sensors and manual override controls.
- C. Daylighting Control Photo Sensors: Low voltage class 2 photo sensor units with output signal proportional to the measured light level and provision for zero or offset based signal.
 1. Sensor Type: Filtered silicon photo diode.

2. Sensor Range:
 - a. Indoor Photo Sensors: 5 to 100 footcandles.
3. Finish: White unless otherwise indicated.
- D. Dimming Photo Sensors: Photo sensor units with integral controller compatible with specified dimming ballasts, for direct continuous dimming of up to 50 ballasts.
- E. Daylighting Control Switching Modules for Low Voltage Sensors: Low voltage class 2 control unit compatible with specified photo sensors, for switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
 1. Operation: Unless otherwise indicated, load to be turned on when light level is below selected low set point and load to be turned off when light level is above selected high set point, with a no switching dead band between set points to prevent unwanted cycling.
 2. Input Delay: To prevent unwanted cycling due to intermittent light level fluctuations.
 3. Control Capability:
 - a. Single Zone Switching Modules: Capable of controlling one programmable channel.
 - b. Multi-Zone Switching Modules: Capable of controlling up to three separately programmable channels.
- F. Daylighting Control Dimming Modules for Low Voltage Sensors: Low voltage class 2 control unit compatible with specified photo sensors and with specified dimming ballasts, for both continuous dimming of compatible dimming ballasts and switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
 1. Operation: Unless otherwise indicated, specified load to be continuously brightened as not enough daylight becomes available and continuously dimmed as enough daylight becomes available.
 2. Control Capability: Capable of controlling up to three separately programmable channels, with up to 50 ballasts per channel.
 3. Dimming and Fade Rates: Adjustable from 5 to 60 seconds.
 4. Cut-Off Delay: Selectable and adjustable from 0 to 20 minutes.
- G. Power Packs for Low Voltage Daylighting Control Modules:
 1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage daylighting control modules for switching of line voltage loads. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
 2. Input Supply Voltage: Dual rated for 120/277 V ac.
 3. Load Ratings: As required to control the load indicated on drawings.

2.04 ROOM CONTROLLERS

- A. Acceptable Manufacturer:
 1. Crestron Controls
 - a. System: ZumLink-J-Box Series
 - b. Or approved equivalent
 2. Basis of Design: Crestron Zumlink-JBox-16A-LV Load Controller; junction box mount, 0-10V dimmer, 16A capacity, 100-277V with link communication or subject to compliance and prior approval with specified requirements of this section, only of the following:
 - a. Crestron controls or equal

- B. Room Controllers are fully functional out of the box to the connected devices in the space without commissioning or the use of any tools. Room Controllers shall be provided to match the room lighting load and control requirements. The controllers will include line voltage wiring space and will not require additional electrical junction boxes. The control units will include the following features:
1. Fully functional room configuration to the most energy-efficient sequence of operation based upon the connected devices in the room.\
 2. Simple replacement - Using the automatic configuration capabilities, a Room Controller may be replaced with an off-the-shelf unit without requiring any configuration
 3. Quick Installation features including:
 - a. Included line voltage space to simplify wiring and eliminate the need for separate junction boxes.
 - b. Included emergency voltage space to simplify wiring of emergency luminaire connections.
 - c. Breakouts for direct conduit connection.
 - d. Line and low voltage sections include conduit connection points. Systems that require special accessories for direct conduit connections may not comply with local building codes and shall not be acceptable.
 - e. Quick low voltage connections using standard RJ-45 QuickConnect cable.
 - f. Plenum Rated.
 - g. Dual Voltage (120/277 VAC, 60Hz).
 - h. Zero cross circuitry for each load.
 - i. Efficient 150mA switching power supply.
 - j. (2) RJ-45 Click & Go local network ports.
 - k. All models support local network connections of wallstations, occupancy-based controls and receptacle controls.
 4. On/Off/Dimming Room Controllers shall include:
 - a. All models support local network connections of wallstations, occupancy-based controls and receptacle controls.
 - b. (2) SPST Switches, (2) 0-10V analog output dimming controls of compatible LED drivers.

2.05 UNIVERSAL VOLTAGE POWER PACKS

- A. Power Pack:
1. Universal Voltage: 100-277VAC; 50/60Hz
 2. Automatic voltage detection
 3. Electrical load switching capacity: maximum of 20Amps
 4. Regulated 24VDC current; 150mA output
 5. Zero Arc Point Switching
 6. Plenum Rated
 7. Mounts: inside or outside of junction box; inside fixture
 8. Available with exclusive Quick-to-install (QTI) connector
 9. Companion AUX relay device available (MPSA)
 10. UL and cUL listed
 11. Five-year limited warranty
 12. Low voltage device: 24VDC
 13. Manual on/off control

2.06 LOW VOLTAGE SWITCHES/KEYPADS

- A. Crestron controls: Zumlink-BTN4-W (White) with pad printed labels
- B. (4) Button with presets as follows: "All On", "Scene 1" - program so lights automatically adjust to 60% dimmed, "Scene 2" - program so lights automatically adjust to 30% dimmed, and "All off"
- C. Switches/Keypads shall be compatible with selected Room Controller and Buttons shall be configurable
- D. Connect via low voltage cabling.
 - 1. Connect to Room Controller within room.
 - 2. Have ability to daisy chain to other switch(es) within room.

2.07 ACCESSORIES

- A. Auxiliary Contacts:
 - 1. Comply with NEMA IA 10039.
 - 2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each lighting contactor, minimum.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.
- G. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install lighting control devices in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of lighting control devices provided under this section.
- C. Install lighting control devices in accordance with manufacturer's instructions.
- D. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E. Install lighting control devices plumb and level, and held securely in place.
- F. Where required and not furnished with lighting control device, provide wall plate in accordance with Section 262726.
- G. Provide required supports in accordance with Section 260529.

- H. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- I. Occupancy Sensor Locations:
 - 1. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors a minimum of 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturer's recommendations, in order to minimize false triggers.
- J. Daylighting Control Photo Sensor Locations:
 - 1. Unless otherwise indicated, locate photo sensors for closed loop systems to accurately measure the light level controlled at the designated task location, while minimizing the measured amount of direct light from natural or artificial sources such as windows or pendant luminaires.
 - 2. Unless otherwise indicated, locate photo sensors for open loop systems to accurately measure the level of daylight coming into the space, while minimizing the measured amount of lighting from artificial sources.
- K. Lamp Burn-In: Operate lamps at full output for minimum of 100 hours or prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Inspect each lighting control device for damage and defects.
- C. Test occupancy sensors to verify proper operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.
- D. Test daylighting controls to verify proper operation, including light level measurements and time delays where applicable. Record test results in written report to be included with submittals.
- E. Correct wiring deficiencies and replace damaged or defective lighting control devices.

3.04 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust occupancy sensor settings to minimize undesired activations while optimizing energy savings, and to achieve desired function as indicated or as directed by Architect.
- C. Where indicated or as directed by Architect, install factory masking material or adjust integral blinders on passive infrared (PIR) and dual technology occupancy sensor lenses to block undesired motion detection.
- D. Adjust daylighting controls under optimum lighting conditions after all room finishes, furniture, and window treatments have been installed to achieve desired operation as indicated or as directed by Architect. Record settings in written report to be included with submittals. Readjust controls calibrated prior to installation of final room finishes, furniture, and window treatments that do not function properly as determined by Architect.

3.05 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.06 COMMISSIONING

- A. All light fixtures and associated controls (dimmer switches, occupancy sensors, vacancy sensors, photo sensors, room controls, lighting relay control panels/master controllers, etc. must be fully commissioned and adjusted to site specific settings. This shall be performed by a certified manufacturer's rep. All settings must be documented and turned over to owner as part of the O/M manuals.
- B. Interconnections between the master lighting control panel and the building automation system shall be provided by the contractor. All final onsite programming and owner specific required settings shall be provided by certified manufacturer's rep.
- C. See Section 019113 - General Commissioning Requirements for commissioning requirements.

3.07 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. Demonstration: Demonstrate proper operation of lighting control devices to Architect, and correct deficiencies or make adjustments as directed.
- C. Training: Train Owner's personnel on operation, adjustment, programming, and maintenance of lighting control devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Qualified contractor familiar with the project and with sufficient knowledge of the installed lighting control devices.
 - 4. Location: At project site.

END OF SECTION 260923

**SECTION 262416
PANELBOARDS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Lighting and appliance panelboards.
- B. Overcurrent protective devices for panelboards.

1.02 RELATED REQUIREMENTS

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.

1.03 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service; 2013e, with Amendments (2022).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards; 2025.
- D. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- E. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2008 (Reaffirmed 2020).
- F. NEMA BS 31047 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013 (Reaffirmed 2023).
- G. NEMA PB 1 - Panelboards; 2011.
- H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.
- I. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.
- K. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.
- L. UL 67 - Panelboards; Current Edition, Including All Revisions.
- M. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.
- N. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.
- O. UL 869A - Reference Standard for Service Equipment; Current Edition, Including All Revisions.
- P. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.
- Q. UL 1053 - Ground-Fault Sensing and Relaying Equipment; Current Edition, Including All Revisions.
- R. UL 1699 - Arc-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of panelboards and adjacent equipment with all required clearances indicated.
 - 2. Include wiring diagrams showing all factory and field connections.
 - 3. Identify mounting conditions required for equipment seismic qualification.
- D. Manufacturer's equipment seismic qualification certification.
- E. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 1 as routine tests.
- F. Field Quality Control Test Reports.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
- I. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
- J. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.
 - 2. Panelboard Keys: Two of each different key.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

1.08 FIELD CONDITIONS

- A. Maintain ambient temperature within the following limits during and after installation of panelboards:
 - 1. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
 - 2. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Eaton Corporation; _____: www.eaton.com/#sle.
- B. Schneider Electric; Square D Products; _____: www.schneider-electric.us/#sle.
- C. Substitutions: See Section 016000 - Product Requirements.
- D. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 PANELBOARDS - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Seismic Qualification: Provide panelboards and associated components suitable for application under the seismic design criteria specified in Section 260548 where required. Include certification of compliance with submittals.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature:
 - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
 - b. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.
- D. Short Circuit Current Rating:
 - 1. Provide panelboards with listed short circuit current rating as indicated on the drawings.
 - 2. Listed series ratings are not acceptable.
- E. Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.

- F. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- G. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- H. Bussing: Sized in accordance with UL 67 temperature rise requirements.
 - 1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
 - 2. Provide 200 percent rated neutral bus and lugs where indicated.
 - 3. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
 - 4. Provide separate isolated/insulated ground bus where indicated.
- I. Conductor Terminations: Suitable for use with the conductors to be installed.
- J. Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R Type 3R and Type 4X as indicated on drawings
 - 2. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide wiring gutters sized to accommodate the conductors to be installed.
 - b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
 - c. Provide removable end walls for NEMA Type 1 enclosures.
 - d. Provide painted steel boxes for surface-mounted panelboards where exposed to public view, finish to match fronts.
 - 3. Fronts:
 - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
 - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
 - c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
 - 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- K. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- L. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
 - 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
 - 2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
 - a. Use zero sequence ground fault detection method unless otherwise indicated.
 - b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
- M. Provide the following features and accessories where indicated or where required to complete installation:
 - 1. Feed-through lugs.
 - 2. Sub-feed lugs.

2.03 LIGHTING AND APPLIANCE PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
 - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
 - 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
 - 2. Phase and Neutral Bus Material: Copper.
 - 3. Ground Bus Material: Copper.
- D. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.
- E. Enclosures:
 - 1. Provide surface-mounted or flush-mounted enclosures as indicated.
 - 2. Fronts: Provide door-in-door trim with full lengthed piano hinged cover for access to load terminals and wiring gutters, and separate lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
 - 3. Provide clear plastic circuit directory holder mounted on inside of door.

2.04 OVERCURRENT PROTECTIVE DEVICES

- A. Fusible Switches:
 - 1. Description: Quick-make, quick-break, dead-front fusible switch units complying with NEMA BS 31047, and listed and labeled as complying with UL 98; ratings, configurations, and features as indicated on the drawings.
 - 2. Fuse Clips: As required to accept indicated fuses.
 - a. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.
 - 3. Provide externally operable handle with means for locking in the OFF position. Provide means for locking switch cover in the closed position. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
 - 4. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Copper, suitable for terminating copper conductors only.
- B. Molded Case Circuit Breakers:
 - 1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 - 2. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - 1) 22,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - 2) 25,000 rms symmetrical amperes at 480 VAC.

- b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
- 3. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Copper, suitable for terminating copper conductors only.
- 4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 - a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
 - b. Provide interchangeable trip units where indicated.
- 5. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - a. Provide the following field-adjustable trip response settings:
 - 1) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
 - 2) Long time delay.
 - 3) Short time pickup and delay.
 - 4) Instantaneous pickup.
 - 5) Ground fault pickup and delay where ground fault protection is indicated.
- 6. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
- 7. Provide the following circuit breaker types where indicated:
 - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
 - b. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
 - c. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
 - d. 100 Percent Rated Circuit Breakers: Listed for application within the panelboard where installed at 100 percent of the continuous current rating.
 - e. Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
- 8. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.
- 9. Provide the following features and accessories where indicated or where required to complete installation:
 - a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
 - b. Handle Pad-Lock Provision: For locking circuit breaker handle in OFF position.
 - c. Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.

2.05 SOURCE QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Factory test panelboards according to NEMA PB 1.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.

- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 260529.
- F. Install panelboards plumb.
- G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- I. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- J. Provide grounding and bonding in accordance with Section 260526.
 - 1. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on isolated/insulated ground bus.
 - 2. Terminate branch circuit isolated grounding conductors on isolated/insulated ground bus only. Do not terminate on solidly bonded equipment ground bus.
- K. Install all field-installed branch devices, components, and accessories.
- L. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed according to Section 260573.
- M. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- N. Provide filler plates to cover unused spaces in panelboards.
- O. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:
 - 1. Fire detection and alarm circuits.
- P. Identify panelboards in accordance with Section 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Fusible Switches: Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
- D. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than _____ amperes. Tests listed as optional are not required.

- E. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- F. Test GFCI circuit breakers to verify proper operation.
- G. Test AFCI circuit breakers to verify proper operation.
- H. Test shunt trips to verify proper operation.
- I. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

3.05 CLEANING

- A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION 262416

**SECTION 262726
WIRING DEVICES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Wall switches.
- B. Wall dimmers.
- C. Receptacles.
- D. Wall plates.

1.02 RELATED REQUIREMENTS

- A. Section 260533.16 - Boxes for Electrical Systems.
- B. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- C. Section 260923 - Lighting Control Devices: Devices for automatic control of lighting, including occupancy sensors, in-wall time switches, and in-wall interval timers.
- D. Section 271000 - Structured Cabling: Voice and data jacks.

1.03 REFERENCE STANDARDS

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for; 2014h (Validated 2022).
- B. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification); 2017g (Validated 2023).
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.
- D. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2016.
- E. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (Reaffirmed 2020).
- F. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2021.
- G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 20 - General-Use Snap Switches; Current Edition, Including All Revisions.
- I. UL 498 - Attachment Plugs and Receptacles; Current Edition, Including All Revisions.
- J. UL 514D - Cover Plates for Flush-Mounted Wiring Devices; Current Edition, Including All Revisions.
- K. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.
- L. UL 1472 - Solid-State Dimming Controls; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
 - 3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.

4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
 5. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.
- B. Sequencing:
1. Do not install wiring devices until final surface finishes and painting are complete.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.
1. Wall Dimmers: Include derating information for ganged multiple devices.
- C. Operation and Maintenance Data:
1. Wall Dimmers: Include information on operation and setting of presets.
 2. GFCI Receptacles: Include information on status indicators.
- D. Project Record Documents: Record actual installed locations of wiring devices.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 016000 - Product Requirements, for additional provisions.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS

2.01 WIRING DEVICE APPLICATIONS

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.
- D. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- E. Provide GFCI protection for receptacles installed in kitchens.
- F. Provide GFCI protection for receptacles serving electric drinking fountains.
- G. Unless noted otherwise, do not use combination switch/receptacle devices.

2.02 WIRING DEVICE FINISHES

- A. Provide wiring device finishes as described below unless otherwise indicated.
- B. Wiring Devices, Unless Otherwise Indicated: White with white stainless steel wall plate.
- C. Wiring Devices Installed in Finished Spaces: White with white stainless steel wall plate.
- D. Wiring Devices Installed in Unfinished Spaces: White with galvanized steel wall plate.
- E. Wiring Devices Installed in Wet or Damp Locations: White with specified weatherproof cover.

2.03 WALL SWITCHES

- A. Manufacturers:
 - 1. Hubbell Incorporated: www.hubbell.com/#sle.
 - 2. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us/#sle.
- B. Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable, FS W-S-896; types as indicated on the drawings.
 - 1. Wiring Provisions: Terminal screws for side wiring and screw actuated binding clamp for back wiring with separate ground terminal screw.
- C. Standard Wall Switches: Industrial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw as indicated on the drawings.

2.04 WALL DIMMERS

- A. Manufacturers:
 - 1. Leviton Manufacturing Company, Inc
 - 2. Lutron Electronics Company, Inc
 - 3. Pass & Seymour, a brand of Legrand North America, Inc
 - 4. Substitutions: See Section 016000 - Product Requirements.
- B. Wall Dimmers - General Requirements: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1472; types and ratings suitable for load controlled as indicated on the drawings.

2.05 RECEPTACLES

- A. Manufacturers:
 - 1. Hubbell Incorporated: www.hubbell.com/#sle.
 - 2. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us/#sle.
 - 3. Substitutions: See Section 016000 - Product Requirements.
- B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
 - 1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
 - 2. NEMA configurations specified are according to NEMA WD 6.
- C. Convenience Receptacles:
 - 1. Standard Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
 - 2. Weather Resistant Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.
- D. GFCI Receptacles:
 - 1. GFCI Receptacles - General Requirements: Self-testing, with feed-through protection and light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.

- a. Provide test and reset buttons of same color as device.
2. Standard GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
3. Weather Resistant GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.

2.06 WALL PLATES

- A. Manufacturers:
 1. Hubbell Incorporated: www.hubbell-wiring.com/#sle.
 2. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us/#sle.
- B. Wall Plates: Comply with UL 514D.
 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
 2. Size: Standard.
 3. Screws: Metal with slotted heads finished to match wall plate finish.
- C. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.
- D. Galvanized Steel Wall Plates: Rounded corners and edges, with corrosion resistant screws.
- E. Weatherproof Covers for Wet or Damp Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- F. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.03 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of wiring devices provided under this section.
 1. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
 2. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.

- 3. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect to obtain direction prior to proceeding with work.
- 4. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.
- C. Install wiring devices in accordance with manufacturer's instructions.
- D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
- G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- H. Where split-wired duplex receptacles are indicated, remove tabs connecting top and bottom receptacles.
- I. Install wiring devices plumb and level with mounting yoke held rigidly in place.
- J. Install wall switches with OFF position down.
- K. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.
- L. Do not share neutral conductor on branch circuits utilizing wall dimmers.
- M. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- N. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- O. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
- P. Identify wiring devices in accordance with Section 260553.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Inspect each wiring device for damage and defects.
- C. Operate each wall switch and wall dimmer with circuit energized to verify proper operation.
- D. Test each receptacle to verify operation and proper polarity.
- E. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- F. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.05 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.

- B. Adjust presets for wall dimmers according to manufacturer's instructions as directed by Architect.

3.06 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION 262726

**SECTION 265100
INTERIOR LIGHTING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Interior luminaires.
- B. Emergency lighting units
- C. Exit signs.
- D. Ballasts and drivers.
- E. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 260529 - Hangers and Supports for Electrical Systems.
- B. Section 260533.16 - Boxes for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 262726 - Wiring Devices: Manual wall switches and wall dimmers.

1.03 REFERENCE STANDARDS

- A. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code); 1989 (Corrigendum 2019).
- B. IES LM-63 - Approved Method: IES Standard File Format for the Electronic Transfer of Photometric Data and Related Information; 2019.
- C. IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products; 2024.
- D. IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources; 2021.
- E. NECA/IESNA 500 - Standard for Installing Indoor Commercial Lighting Systems; 2025.
- F. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems; 2006.
- G. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility; 2023.
- H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. NFPA 101 - Life Safety Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- J. UL 844 - Luminaires for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.
- K. UL 924 - Emergency Lighting and Power Equipment; Current Edition, Including All Revisions.
- L. UL 1598 - Luminaires; Current Edition, Including All Revisions.
- M. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
4. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.05 SUBMITTALS

- A. See Section 013300 Submittal Procedures, for submittal procedures.
- B. Shop Drawings:
 1. Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
 2. Provide photometric calculations where luminaires are proposed for substitution as part or lighting submittals.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
 1. LED Luminaires:
 - a. Include estimated useful life, calculated based on IES LM-80 test data.
 2. Provide electronic files of photometric data certified by a National Voluntary Laboratory Accreditation Program (NVLAP) lab or independent testing agency in IES LM-63 standard format upon request.
- D. Samples:
 1. Provide one sample(s) of each luminaire proposed for substitution upon request.
 2. Provide one sample(s) of each product finish illustrating color and texture upon request.
- E. Certificates for Dimming Ballasts: Manufacturer's documentation of compatibility with dimming controls to be installed.
- F. Field quality control reports.
- G. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 016000 - Product Requirements, for additional provisions.
 2. Extra Lenses and Louvers: Two percent of total quantity installed for each type, but not less than one of each type.
 3. Extra drivers: Two percent of total quantity installed for each type, but not less than one of each type.

- J. Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.08 FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.09 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for LED luminaires, including drivers.
- C. Provide five year full warranty for batteries for emergency lighting units. Life time warranty for LEDs.
- D. Provide three year full warranty and seven year pro-rata warranty for batteries for self-powered exit signs.

PART 2 PRODUCTS

2.01 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the drawings.
- B. Substitutions: See Section 016000 - Product Requirements except where individual luminaire types are designated with substitutions not permitted.

2.02 LUMINAIRES

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.

- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. Recessed Luminaires:
 - 1. Ceiling Compatibility: Comply with NEMA LE 4.
 - 2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
 - 3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.
 - 4. Air-Handling Recessed Fluorescent Luminaires: Suitable for air supply/return, heat removal, or combination as indicated.
 - a. Luminaires for Air Supply/Return: Provide air control blades where indicated.
- H. LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- I. Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

2.03 EMERGENCY LIGHTING UNITS

- A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
- B. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- C. Battery:
 - 1. Sealed maintenance-free Nickel metal hydride (NiMH) unless otherwise indicated.
 - 2. Size battery to supply all connected lamps, including emergency remote heads where indicated.
- D. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- E. Provide low-voltage disconnect to prevent battery damage from deep discharge.
- F. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.
- G. Accessories:
 - 1. Provide compatible accessory mounting brackets where indicated or required to complete installation.
 - 2. Provide compatible accessory high impact polycarbonate vandal shields where indicated.
 - 3. Provide compatible accessory wire guards where indicated.
 - 4. Where indicated, provide emergency remote heads that are compatible with the emergency lighting unit they are connected to and suitable for the installed location.

2.04 EXIT SIGNS

- A. Description: Exit signs complying with NFPA 101 and applicable state and local codes, and listed and labeled as complying with UL 924.
 - 1. Number of Faces: Single- or double-face as indicated or as required for installed location.
 - 2. Directional Arrows: As indicated or as required for installed location.
- B. Powered Exit Signs: Internally illuminated with LEDs unless otherwise indicated.
 - 1. Self-Powered Exit Signs:
 - a. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
 - b. Battery: Sealed, maintenance-free, Nickel metal hydride (NiMH) unless otherwise indicated.
 - c. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
 - d. Provide low-voltage disconnect to prevent battery damage from deep discharge.
 - e. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.
- C. Accessories:
 - 1. Provide compatible accessory high-impact polycarbonate vandal shields where indicated.
 - 2. Provide compatible accessory wire guards where indicated.

2.05 DRIVERS

- A. Ballasts/Drivers - General Requirements:
 - 1. Provide ballasts containing no polychlorinated biphenyls (PCBs).
 - 2. Minimum Efficiency/Efficacy: Provide ballasts complying with all current applicable federal and state ballast efficiency/efficacy standards.
- B. Dimmable LED Drivers:
 - 1. Dimming Range: Continuous dimming from 100 percent to one percent relative light output unless dimming capability to lower level is indicated, without flicker.
 - 2. Control Compatibility: Fully compatible with the dimming controls to be installed.
 - a. Lighting Control devices: See Section 260923.

2.06 ACCESSORIES

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.
- C. Provide accessory plaster frames for luminaires recessed in plaster ceilings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.

- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.03 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of luminaires provided under this section.
- B. Install products in accordance with manufacturer's instructions.
- C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).
- D. Provide required support and attachment in accordance with Section 260529.
- E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F. Suspended Ceiling Mounted Luminaires:
 - 1. Do not use ceiling tiles to bear weight of luminaires.
 - 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
 - 3. Secure surface-mounted and recessed luminaires to ceiling support channels or framing members or to building structure.
 - 4. Secure pendant-mounted luminaires to building structure.
 - 5. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
 - 6. In addition to ceiling support wires, provide two galvanized steel safety wire(s), minimum 12 gauge, connected from opposing corners of each recessed luminaire to building structure.
 - 7. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- G. Recessed Luminaires:
 - 1. Install trims tight to mounting surface with no visible light leakage.
 - 2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
 - 3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.
- H. Suspended Luminaires:
 - 1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
 - 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 - 3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet nominal length, with no more than 4 feet between supports.
 - 4. Install canopies tight to mounting surface.

- I. Install accessories furnished with each luminaire.
- J. Bond products and metal accessories to branch circuit equipment grounding conductor.
- K. Air Handling luminaires: Interface with air handling accessories furnished and installed under Section 233600.
- L. Emergency Lighting Units:
 - 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
 - 2. Install lock-on device on branch circuit breaker serving units.
- M. Exit Signs:
 - 1. Install lock-on device on branch circuit breaker serving units.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Test self-powered exit signs, emergency lighting units, and fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.
- E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

3.05 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.
- B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by Architect or authority having jurisdiction.
- C. Air-Handling luminaires with Air Control Blades or Heat Removal Dampers: Adjust as indicated or as required for proper airflow as directed by Architect.
- D. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Architect or authority having jurisdiction.

3.06 CLEANING

- A. Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.07 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.
- D. Just prior to Substantial Completion, LED's or drivers that have failed.

3.08 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION 265100

SECTION 270000
– COMMUNICATIONS INSTALLATION OVERVIEW

PART 1 INSTALLATION OVERVIEW

1.01 SUMMARY

- A. This project encompasses the installation of high capacity cabling backbone and associated hardware to support high-bandwidth communications. Also included in the communications scope are Unshielded Twisted Pair Cabling.

1.02 THE COMPONENTS ASSOCIATED WITH THIS PROJECT ARE:

- A. Conduit and Wiremold will be used to provide a protected pathway for all cables routed or installed in an exposed environment. The pathways for this project are included in the Division 26000 series of specifications.
- B. CAT6, 350 MHz twisted pair cabling (as specified) will be home run between each telephone and data drop location to the nearest telecom closet (TC).
- C. Fiber optical cabling

1.03 RELATED SECTIONS

- A. Drawings and general provisions of contract, including General and Supplementary conditions and Division 1 Specifications sections, apply to work in this section.
- B. Division 26 and 27 Sections apply to work in this section.

PART 2 INSTALLATION PROCESS

2.01 INSTALLATION OF CONDUIT AND WIREMOLD

- A. Unless otherwise stated on drawings, Electrical Contractor under Division 26 of this specification is to provide and install conduit and/or Wiremold in all situations where cabling exits ceiling cavities. All proposed cable routes and drop locations are approximate and should be verified by the contractor. Cable lengths indicated are approximate. It is the contractor responsibility to verify cable distances prior to cutting and routing of cables. It is the contractor responsibility to verify locations and quantities of drops.
- B. All vertical cable runs between floors will be routed in conduit unless installed in a designated wiring closet, existing ceiling cavity, or specified differently. Vertical conduit runs shall be floor to ceiling or terminate in drop ceiling cavities. In all locations, penetration into the corridor ceiling cavities will be continuous and require the replacement of fire stop materials.
- C. All core drills that are required shall be provided by the electrical contractor, unless otherwise noted. It is the responsibility of the contractor to verify locations with school officials prior to drilling and to fire stop in accordance with local and state codes.

PART 3 EXECUTION

3.01 CABLING

- A. All cables shall be routed in accordance with state and local codes and regulations. All cables installed and terminated shall follow the guidelines set forth by the manufacturer. When routing cables through ceiling cavities all cables shall be supported by bridal rings in a bundled manor and shall not be supported or rest on drop ceiling components. Cables shall be neatly swept and bundled. The maximum allowable cable sag between supports will be 6 inches as measured vertically. All cable will be run to deck height while in ceiling cavities and fastened to roof supports or the bottom of the deck. Refer to project drawings for additional details.

B. Drop locations

1. Drop locations and types are as specified on the associated drawings. All locations are approximate and should be verified with district personnel prior to implementation.

3.02 LABELING

- A. All cables are to be labeled at both the origination and termination locations using as specified a permanent alpha numeric cabling system. Cables shall be labeled at all junction points where a single continuous cable is not used, such as in a splice panel or Demarc.
- B. Each faceplate shall have identification, which includes the cable number, and drop number if more than one of the same type of drop is installed in the room.
- C. Testing
- D. CAT6, Coax and fiber optic cables will be tested as per manufacturers' criteria, EIA/TIA and test specifications identified in this design.

PART 4 COMPLETION**4.01 PROJECT COMPLETION**

- A. All documentation will be completed as specified. All cabling will be neat and secure.
- B. Passing of data from each drop location will be done as specified, in conjunction with Owner. Refer to testing in the general specification section.
- C. All facilities such as walls, ceilings etc., shall be restored to as found or better condition. All fire barriers breached shall be restored / sealed as to local, state and federal codes.
- D. The removal of any construction or installation debris as a result of this project.
- E. The Owner is to be consulted on any alterations of wiring closets, riser locations, and drop locations as required. Should conflicts between this design and the actual install or should any unforeseen circumstance occur during installation the contractor shall consult immediately with an authorized agent of the Owner.

END OF SECTION 270000

**SECTION 271000
STRUCTURED CABLING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Communications system design requirements.
- B. Communications pathways.
- C. Copper cable and terminations.
- D. Communications equipment room fittings.
- E. Communications outlets.
- F. Communications grounding and bonding.
- G. Communications identification.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - PENETRATION FIRESTOPPING.
- B. Section 260533.16 - Boxes for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products.
- D. Section 262726 - Wiring Devices.

1.03 REFERENCE STANDARDS

- A. BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition; 2019.
- B. EIA/ECA-310 - Cabinets, Racks, Panels, and Associated Equipment; 2005e.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. TIA-568 (SET) - Commercial Building Telecommunications Cabling Standard Set; 2024.
- E. TIA-568.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards; 2018d, with Addenda (2020).
- F. TIA-569 - Telecommunications Pathways and Spaces; 2019e, with Addendum (2022).
- G. TIA-606 - Administration Standard for Telecommunications Infrastructure; 2021d.
- H. TIA-607 - Telecommunications Bonding and Grounding (Earthing) for Customer Premises; 2024e.
- I. UL 444 - Communications Cables; Current Edition, Including All Revisions.
- J. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers; Current Edition, Including All Revisions.
- K. UL 1863 - Communications-Circuit Accessories; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for communications equipment.
 - 2. Coordinate arrangement of communications equipment with the dimensions and clearance requirements of the actual equipment to be installed.

3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week prior to commencing work of this section to review service requirements and details with Communications Service Provider representative.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.
- C. Shop Drawings: Show compliance with requirements on isometric schematic diagram of network layout, showing cable routings, telecommunication closets, rack and enclosure layouts and locations, service entrance, and grounding, prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
- D. Evidence of qualifications for installer.
- E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- F. Test Plan: Complete and detailed plan, with list of test equipment, procedures for inspection and testing, and intended test date; submit at least 60 days prior to intended test date.
- G. Field Test Reports.
- H. Project Record Documents: Prepared and approved by BICSI Registered Communications Distribution Designer (RCDD).
 1. Record actual locations of outlet boxes and distribution frames.
 2. Show as-installed color coding, pair assignment, polarization, and cross-connect layout.
 3. Identify distribution frames and equipment rooms by room number on drawings.
- I. Operation and Maintenance Data: List of all components with part numbers, sources of supply, and operation and maintenance instructions; include copy of project record documents.

1.06 QUALITY ASSURANCE

- A. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- B. Manufacturer Qualifications: At least 3 years experience manufacturing products of the type specified.
- C. Installer Qualifications: A company having at least 3 years experience in the installation and testing of the type of system specified, and:
 1. Employing a BICSI Registered Communications Distribution Designer (RCDD).
 2. Supervisors and installers factory certified by manufacturers of products to be installed.
 3. Employing BICSI Registered Cabling Installation Technicians (RCIT) for supervision of all work.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.
- E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Store products in manufacturer's unopened packaging until ready for installation.
- B. Keep stored products clean and dry.

1.08 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a 2 year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN

- A. Provide a complete permanent system of cabling and pathways for voice and data communications, including cables, conduits and wireways, pull wires, support structures, enclosures and cabinets, and outlets.
 - 1. Comply with TIA-568 (SET) (cabling) and TIA-569 (pathways) (commercial standards).
 - 2. Provide fixed cables and pathways that comply with NFPA 70 and TIA-607 and are UL listed or third party independent testing laboratory certified.
 - 3. Provide connection devices that are rated for operation under conditions of 32 to 140 degrees F at relative humidity of 0 to 95 percent, noncondensing.
 - 4. In this project, the term plenum is defined as return air spaces above ceilings, inside ducts, under raised floors, and other air-handling spaces.
- B. Cabling to Outlets: Specified horizontal cabling, wired in star topology to distribution frame located at center hub of star; also referred to as "links".

2.02 PATHWAYS

- A. Conduit: See section 260533.13.
- B. Firestop Sleeves: Listed; provide as required to preserve fire resistance rating of building elements.

2.03 COPPER CABLE AND TERMINATIONS

- A. Manufacturers:
 - 1. CommScope; _____: www.commscope.com/#sle.
 - 2. General Cable Technologies Corporation; _____: www.generalcable.com/#sle.
- B. Copper Horizontal Cable:
 - 1. Description: 100 ohm, balanced twisted pair cable complying with TIA-568.2 and listed and labeled as complying with UL 444.
 - 2. Cable Type - Voice, Wireless Access Points, and Data: TIA-568.2 Category 6A UTP (unshielded twisted pair); 23 AWG.
 - 3. Cable Capacity: 4-pair.
 - 4. Cable Applications: Use listed NFPA 70 Type CMP plenum cable unless otherwise indicated.
 - 5. Cable Jacket Color - Voice and Data Cable: Blue; Wireless Access Points: Green.
 - 6. Product(s):
 - a. CommScope; SYSTIMAX Twisted Pair Cables; GigaSPEED XL Category 6A U/UTP Cable: www.commscope.com/#sle.
 - b. CommScope; Uniprise Twisted Pair Cables; CS44 Series Category 6A U/UTP Cable: www.commscope.com/#sle.
 - c. General Cable Technologies Corporation; GenSPEED Cables: www.generalcable.com/#sle.

- C. Copper Cable Terminations: Insulation displacement connection (IDC) type using appropriate tool; use screw connections only where specifically indicated.
- D. Jacks and Connectors: Modular RJ-45, non-keyed, terminated with 110-style insulation displacement connectors (IDC); high impact thermoplastic housing; suitable for and complying with same standard as specified horizontal cable; UL 1863 listed.
 - 1. Performance: 500 mating cycles.
 - 2. Voice and Data Jacks: 8-position modular jack, color-coded for both T568A and T568B wiring configurations.
 - 3. Product(s):
 - a. CommScope; SYSTIMAX RJ45 Jacks; MGS600 Series Category 6A U/UTP Modular Jacks: www.commscope.com/#sle.
 - b. CommScope; Uniprise RJ45 Jacks; Ultra 10 UNJ10G Series Category 6A U/UTP Modular Jacks: www.commscope.com/#sle.
- E. Copper Patch Cords:
 - 1. Description: Factory-fabricated 4-pair cable assemblies with 8-position modular connectors terminated at each end.
 - 2. Patch Cords for Patch Panels:
 - a. Quantity: One for each pair of patch panel ports.
 - b. Length: 5 feet.
 - 3. Product(s):
 - a. CommScope; SYSTIMAX Category 6 U/UTP Patch Cords: www.commscope.com/#sle.
 - b. CommScope; Uniprise Category 6 U/UTP Patch Cords: www.commscope.com/#sle.

2.04 COMMUNICATIONS EQUIPMENT ROOM FITTINGS

- A. Copper Cross-Connection Equipment:
 - 1. Connector Blocks for Category 5e and Up Cabling: Type 110 insulation displacement connectors; capacity sufficient for cables to be terminated plus 25 percent spare.
 - 2. Patch Panels for Copper Cabling: Sized to fit EIA/ECA-310 standard 19 inch wide equipment racks; 0.09 inch thick aluminum; cabling terminated on Type 110 insulation displacement connectors; printed circuit board interface.
 - a. Jacks: Non-keyed RJ-45, suitable for and complying with same standard as cable to be terminated; maximum 48 ports per standard width panel.
 - b. Capacity: Provide ports sufficient for cables to be terminated plus 25 percent spare.
 - c. Labels: Factory installed laminated plastic nameplates above each port, numbered consecutively; comply with TIA-606.
 - d. Provide incoming cable strain relief and routing guides on back of panel.
 - 3. Product(s):
 - a. CommScope; SYSTIMAX Copper Panels; 360-IPR-1100-XX Series Patch Panels: www.commscope.com/#sle.

2.05 COMMUNICATIONS OUTLETS

- A. Manufacturers:
 - 1. CommScope; _____: www.commscope.com/#sle.
- B. Outlet Boxes: Comply with Section 260533.16.
 - 1. Provide depth as required to accommodate cable manufacturer's recommended minimum conductor bend radius.
 - 2. Minimum Size, Unless Otherwise Indicated:

- a. Voice Only Outlets: 4 inch by 2 inch by 2-1/8 inch deep (100 by 50 by 54 mm) trade size.
 - b. Data or Combination Voice/Data Outlets: 4 inch square by 2-1/8 inch deep (100 by 54 mm) trade size.
- C. Wall Plates:
 - 1. Comply with system design standards and UL 514C.
 - 2. Accepts modular jacks/inserts.
 - 3. Capacity:
 - a. Voice Only Outlets: 4.
 - b. Data or Combination Voice/Data Outlets: 4 ports.
 - 4. Wall Plate Material/Finish - Flush-Mounted Outlets: Match wiring device and wall plate finishes specified in Section 262726.

2.06 GROUNDING AND BONDING COMPONENTS

- A. Comply with TIA-607.
- B. Comply with Section 260526.

2.07 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606.
- B. Comply with Section 260553.

2.08 SOURCE QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Factory test cables according to TIA-568 (SET).

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

- A. Comply with latest editions and addenda of TIA-568 (SET) (cabling), TIA-569 (pathways), TIA-607 (grounding and bonding), BICSI N1, NFPA 70, and SYSTEM DESIGN as specified in PART 2.
- B. Comply with Communication Service Provider requirements.
- C. Grounding and Bonding: Perform in accordance with TIA-607 and NFPA 70.
- D. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.

3.02 INSTALLATION OF PATHWAYS

- A. Install pathways with the following minimum clearances:
 - 1. 48 inches from motors, generators, frequency converters, transformers, x-ray equipment, and uninterruptible power systems.
 - 2. 12 inches from power conduits and cables and panelboards.
 - 3. 5 inches from fluorescent and high frequency lighting fixtures.
 - 4. 6 inches from flues, hot water pipes, and steam pipes.
- B. Outlet Boxes:
 - 1. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of telecommunications outlets provided under this section.
 - a. Mounting Heights: Unless otherwise indicated, as follows:
 - 1) Telephone and Data Outlets: 18 inches above finished floor.

- b. Provide minimum of 24 inches horizontal separation between flush mounted outlet boxes installed on opposite sides of fire rated walls.

3.03 INSTALLATION OF EQUIPMENT AND CABLING

- A. Cabling:
 - 1. Do not bend cable at radius less than manufacturer's recommended bend radius; for unshielded twisted pair use bend radius of not less than 4 times cable diameter.
 - 2. Do not over-cinch or crush cables.
 - 3. Do not exceed manufacturer's recommended cable pull tension.
 - 4. When installing in conduit, use only lubricants approved by cable manufacturer and do not chafe or damage outer jacket.
- B. Service Loops (Slack or Excess Length): Provide the following minimum extra length of cable, looped neatly:
 - 1. At Distribution Frames: 120 inches.
 - 2. At Outlets - Copper: 12 inches.
- C. Copper Cabling:
 - 1. Category 5e and Above: Maintain cable geometry; do not untwist more than 1/2 inch from point of termination.
 - 2. For 4-pair cables in conduit, do not exceed 25 pounds pull tension.
 - 3. Use T568B wiring configuration.
- D. Identification:
 - 1. Use wire and cable markers to identify cables at each end.
 - 2. Use manufacturer-furnished label inserts, identification labels, or engraved wallplate to identify each jack at communications outlets with unique identifier.
 - 3. Use identification nameplate to identify cross-connection equipment, equipment racks, and cabinets.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - BSD Quality Requirements, for additional requirements.
- B. Comply with inspection and testing requirements of specified installation standards.
- C. Visual Inspection:
 - 1. Inspect cable jackets for certification markings.
 - 2. Inspect cable terminations for color coded labels of proper type.
 - 3. Inspect outlet plates and patch panels for complete labels.
 - 4. Inspect patch cords for complete labels.
- D. Testing - Copper Cabling and Associated Equipment:
 - 1. Test backbone cables after termination but before cross-connection.
 - 2. Test backbone cables for DC loop resistance, shorts, opens, intermittent faults, and polarity between connectors and between conductors and shield, if cable has overall shield.
 - 3. Test operation of shorting bars in connection blocks.
 - 4. Category 5e and Above Backbone: Perform near end cross talk (NEXT) and attenuation tests.
 - 5. Category 5e and Above Links: Perform tests for wire map, length, attenuation, NEXT, and propagation delay.

- E. Final Testing: After all work is complete, including installation of telecommunications outlets, and telephone dial tone service is active, test each voice jack for dial tone.

END OF SECTION 271000

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**SECTION 284601
FIRE ALARM SYSTEM (EXISTING SYSTEM)**

PART 1 - GENERAL**1.01 SCOPE & RELATED DOCUMENTS**

- A. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials, and performance of all operations in connection with the modifications and additions to the existing Fire Alarm System(s) as shown on the drawings and as herein specified.
- B. The requirements of the conditions of the Contract, Supplementary Conditions and General Requirements, apply to the work specified in this section.
- C. The complete installation is to conform to the applicable sections of NFPA-72, NFPA-71, Local Code Requirements and National Electrical Code with particular attention to Article 760.
- D. Additionally, the entire installed system and all integrated system operations shall be within the guidelines of the SBCCI Standard Building Code.
- E. The work covered by this section of the specifications is to be coordinated with the related work as specified elsewhere under the project specifications.
- F. The contractor shall provide all required modifications and additions to the existing Fire Alarm System for the removal, relocation of existing devices and addition of new devices. This shall include all additional wiring, devices, modifications to the existing control panel, additional components and modules, addressable cards, testing, troubleshooting and instructions to the owner.

1.02 QUALITY ASSURANCE

- A. Each and all items of the Fire Alarm System shall be listed compatible with the existing system under the appropriate category by Underwriters' Laboratories, Inc. (UL), and shall bear the "U.L." label. All control equipment is to be listed under UL category UOJZ as a single control unit. Partial listing shall NOT be acceptable.
- B. All items shall match and be of the same manufacturer as the existing system.
- C. The equipment and installation supervision furnished under this specification is to be provided by a manufacturer who has been engaged in production of this type (software driven) of equipment for at least ten (10) years, and has a fully-equipped service organization within thirty-five (35) miles of the installation.
- D. All control equipment must have transient protection devices to comply with UL864 requirements.
- E. In addition to the UL-UOJZ requirement mentioned above, the system controls shall be UL listed for Power Limited Applications per NEC 760. All circuits must be marked in accordance with NEC article 760-23.
- F. Supplier shall provide documentation that fire alarm technicians are NICET LEVEL 2 certified (minimum of four).
- G. Suppliers' service organization must have been established in the local area for a minimum of ten (10) years with ten (10) years experience on specific equipment brand supplied.

1.03 SUBMITTALS

- A. Submit shop drawings for each piece of equipment specified including complete wiring and connection diagrams.
- B. All submittals shall be submitted in a single complete brochure, which shall be in the form of a soft cover binder with each group separated by an identified index tab.
- C. Submittals that fail to comply with the above requirements will automatically be rejected.
- D. It is the Contractor's responsibility to provide submittals in an organized and timely manner in order so as not to delay the project schedule and hamper the work of other trades.
- E. Submit certificate of Fire Alarm System operating tests.

PART 2 PRODUCTS

2.01 PERIPHERAL DEVICES

- A. The Contractor shall furnish and install addressable devices that are compatible with the existing Cerberus Pyrotronics fire alarm System
- B. Devices Required but not limited to:
 - 1. Manual Pull Stations
 - 2. Smoke Detectors
 - 3. Duct Smoke Detectors
 - 4. Combination Speaker/Strobe Stations
 - 5. Visual Alarm (Strobe) Stations
 - 6. Auxiliary contacts on devices where indicated on drawings.
 - 7. Magnetic fire door holds
 - 8. Power Supplies
 - 9. Addressable Relay modules

2.02 MAGNETIC DOOR HOLDERS

- A. Description: Units shall be listed to UL 228. Units shall be equipped for wall or floor mounting as indicated on plans and are complete with matching door plate and extension arms as required. Unit shall operate from a 120VAC, a 24VAC or a 24VDC source from fire alarm panel. Magnets must develop a minimum of 25 lbs. holding force for any of these voltages.
- B. Material and Finish: Match door hardware. All final hardware material and finishes must be coordinate with the GC.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Provide and install all devices in accordance with the plans and specifications, all applicable codes and the manufacturer's recommendations. All wiring shall be installed in strict compliance with all the provisions of NEC - Article 760 A and C, Power-Limited Fire Protective Signaling Circuits or if required may be reclassified as non-power limited and wired in accordance with NEC-Article 760 A and B. Upon completion, the contractor shall so certify in writing to the owner and general contractor.
 - 1. All junction boxes shall be sprayed red and labeled "Fire Alarm". Wiring color code shall be maintained throughout the installation.
- B. Installation of equipment and devices that pertain to other work in the contract shall be closely coordinated with the appropriate subcontractors.
- C. The contractor shall clean all dirt and debris from the inside and the outside of the fire alarm equipment after completion of the installation.

- D. The manufacturer's authorized representative shall provide on-site supervision of installation.

3.02 TESTING

- A. The completed fire alarm system shall be fully tested in accordance with NFPA-72H by the contractor in the presence of the owner's representative and the Local Fire Marshal. Upon completion of a successful test, the contractor shall so certify in writing to the owner and general contractor.

3.03 WARRANTY

- A. The contractor shall warrant the completed fire alarm system wiring and equipment to be free from inherent mechanical and electrical defects for a period of one (1) year from the date of the completed and certified test or from the date of first beneficial use.
- B. The equipment manufacturer shall make available to the owner a maintenance contract proposal to provide a minimum of two (2) inspections and tests per year in compliance with NFPA-72H guidelines.

END OF SECTION 284601