



WAYNE STATE
UNIVERSITY

Project Manual | Volume 02 | Divisions 15 - 33

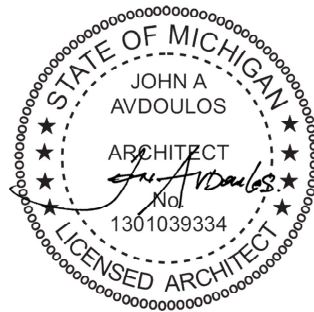
Wayne State University
Health Science Research Building
Detroit, Michigan

Compiled Set
October 17, 2025



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WAYNE STATE UNIVERSITY
HEALTH SCIENCES RESEARCH BUILDING
DETROIT, MICHIGAN



2025-10-17

PROJECT MANUAL
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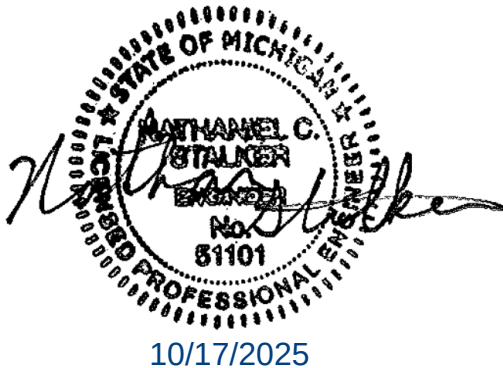
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SECTION 210500
COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Above ground piping.
- B Buried piping.
- C Escutcheons.
- D Mechanical couplings.
- E Pipe hangers and supports.
- F Pipe sleeves.
- G Pipe sleeve-seal systems.
- H Pressure gauges.
- I Pressure relief valves.

1.2 RELATED REQUIREMENTS

- A Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- B Section 210553 - Identification for Fire Suppression Piping and Equipment: Piping identification.
- C Section 211200 - Fire-Suppression Standpipes: Standpipe design.
- D Section 211300 - Fire-Suppression Sprinkler Systems: Sprinkler systems design.

1.3 REFERENCE STANDARDS

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- A ASME A112.18.1 - Plumbing Supply Fittings; 2024.
- B ASME B40.100 - Pressure Gauges and Gauge Attachments; 2022.
- C 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.
- D ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2020.
- E ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.
- F ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250; 2021.
- G ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard; 2020.
- H ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2022).
- I ASTM A269/A269M - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service; 2024.
- J ASTM A536 - Standard Specification for Ductile Iron Castings; 1984, with Editorial Revision (2019).
- K ASTM A795/A795M - Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use; 2021.
- L AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings; 2021.
- M AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings; 2023.
- N AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast; 2023.
- O AWWA C606 - Grooved and Shouldered Joints; 2022.
- P FM (AG) - FM Approval Guide; Current Edition.

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- Q NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- R NFPA 14 - Standard for the Installation of Standpipe and Hose Systems; 2024.
- S NFPA 1963 - Standard for Fire Hose Connections; 2019.
- T UL (DIR) - Online Certifications Directory; Current Edition.
- U UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.
- V UL 405 - Standard for Safety Fire Department Connection Devices; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A See Section Division 1 Administrative Requirements for submittal procedures.
- B Product Data: Provide manufacturer's catalog information. Indicate valve data and ratings.
- C Shop Drawings: Indicate pipe materials used, jointing methods, supports, and floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- D Operation and Maintenance Data: Include installation instructions and spare parts lists.
- E Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Division 1 Product Requirements, for additional provisions.

1.5 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 in this section.
 - 1. Minimum three years experience.
- C Comply with FM (AG) and UL (DIR) requirements.

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- D Valves: Bear FM (AG) and UL (DIR) product listing label or marking. Provide manufacturer's name and pressure rating marked on valve body.
- E Products Requiring Electrical Connection: Listed and classified as suitable for the purpose specified and indicated.
- F Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Deliver and store valves in shipping containers, with labeling in place.
- B Provide temporary protective coating on cast iron and steel valves.
- C Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D Follow all Manufacturer's recommendations when storing products.

1.7 WARRANTY

- A See Division 1017800 - Closeout Submittals for additional warranty requirements.
- B Correct defective Work within a one year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A Combined Sprinkler, Standpipe, and Hose System:
 - 1. Comply with NFPA 13 and NFPA 14.
 - 2. See Sections 211300 and 211200.
- B Welding Materials and Procedures: Comply with ASME BPVC-IX.
- C Provide system pipes, fittings, sleeves, escutcheons, seals, and other related accessories.

2.2 BURIED PIPING

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- A Ductile Iron Pipe: AWWA C151/A21.51.
 - 1. Fittings: AWWA C110/A21.10, standard thickness.
 - 2. Joints: AWWA C111/A21.11, styrene-butadiene rubber (SBR) or vulcanized SBR gasket.
 - 3. Mechanical Couplings: Shaped composition sealing gasket, steel bolts, nuts, and washers.

2.3 ABOVE GROUND PIPING

- A Steel Pipe: ASTM A795 Schedule 10 or ASTM A795 Schedule 40, black.
 - 1. Steel Fittings: ASME B16.5 steel flanges and fittings.
 - 2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings and ASME B16.4, threaded fittings.
 - 3. Malleable Iron Fittings: ASME B16.3, threaded fittings and ASTM A47/A47M.
 - 4. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.
 - 5. Mechanical Formed Fittings: Carbon steel housing with integral pipe stop and O-ring pocked and O-ring, uniformly compressed into permanent mechanical engagement onto pipe.

2.4 PIPE SLEEVES

- A Vertical Piping:
 - 1. Sleeve Length: 1 inch (25 mm) above finished floor.
 - 2. Provide sealant for watertight joint.
 - 3. Blocked Out Floor Openings: Provide 1-1/2 inch (40 mm) angle set in silicon adhesive around opening.
 - 4. Drilled Penetrations: Provide 1-1/2 inch (40 mm) angle ring or square set in silicone adhesive around penetration.
- B Plastic, Sheet Metal, or Moisture-Resistant Fiber: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.
- C Pipe 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.
- D Pipe Passing Through Concrete Beam Flanges, except where Brass Pipe Sleeves are Specified:
 - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 - 2. Connect sleeve with floor plate except in mechanical rooms.
- E Not required for wall hydrants for fire department connections or in drywall construction.

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- F Penetrations in concrete beam flanges are permitted but are prohibited through ribs or beams without prior approval from the Architect.
- G Clearances:
1. Provide allowance for insulated piping.
 2. Wall, Floor, Floor, Partitions, and Beam Flanges: 1 inch (25 mm) greater than external; pipe diameter.
 3. Rated Openings: Caulked tight with firestopping material complying with ASTM E814 in accordance with Division 7078400 to prevent the spread of fire, smoke, and gases.

2.5 PIPE SLEEVE-SEAL SYSTEMS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Advance Products & Systems, Inc.
 2. GPT, a company of Enpro Industries, Inc.
 3. Calpico, Inc..
 4. Metraflex Co..
 5. Pipeline Seal and Insulator, Inc.
 - 6.
- B Modular Mechanical Seals:
1. Elastomer-based interlocking links to 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. Service Requirements:
 - a. Corrosion resistant.
 - b. Oil, fuel, gas, and solvent resistant.
 - c. Underground, buried, and wet conditions.
 - d. Fire Resistance: 1 hour, FM (AG) approved.
 - e. High temperature, up to 400 deg F (204 deg C).
 - f. Low temperature, down to minus 67 deg F (minus 55 deg C).
 5. Glass-reinforced plastic pressure end plates.
- C Wall Sleeve: PVC material with waterstop collar, and nailer end caps.
- D Sleeve-Forming Disk: Nonconductive plastic-based material, 3 inch (76.2 mm) thick.
- E Pipeline-Casing Seals:
1. Coated-metallic boltless casing-spacer for 4 inch (100 mm) carrier pipe.
 2. Coated-metallic boltless modular seal for 6 inch (150 mm) carrier pipe.
 3. Carbon steel band with riser for 12 inch (305 mm) carrier pipe.
 4. End Seals: 1/8 inch (3.1 mm), pull-on type, rubber or synthetic rubber based.

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2.6 ESCUTCHEONS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Fire Protection Products, Inc.
 - 2. Tyco Fire Protection Products.
 - 3. Viking Group Inc.
- B Material:
 - 1. Fabricate from nonferrous metal.
 - 2. Chrome-plated.
 - 3. Grade TP304, seamless tube, ASTM A269/A269M stainless steel.
 - 4. Metals and Finish: Comply with ASME A112.18.1.
- C Construction:
 - 1. One-piece for mounting on chrome-plated tubing or pipe and one-piece or split-pattern type elsewhere.
 - 2. Internal spring tension devices or setscrews to maintain a fixed position against a surface.

2.7 PIPE HANGERS AND SUPPORTS

- A Hangers for Pipe Sizes 1/2 to 1-1/2 inch (15 to 40 mm): Malleable iron, adjustable swivel, split ring.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. AFCON, a brand of Anvil International.
 - b. FNW.
- B Hangers for Pipe Sizes 2 inches (50 mm) and Over: Carbon steel, adjustable, clevis.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. AFCON, a brand of Anvil International.
 - b. FNW.
- C Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- D Wall Support for Pipe Sizes to 3 inches (80 mm): Cast iron hook.
- E Wall Support for Pipe Sizes 4 inches (100 mm) and Over: Welded steel bracket and wrought steel clamp.
- F Vertical Support: Steel riser clamp.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Anvil International.
- G Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Anvil International.
- H Pipe Hanger Fasteners:
 1. Attach hangers to structure using appropriate fasteners, as follows:
 - a. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
 - b. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
 - c. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
 - d. Masonry Screw Type Anchors: Complying with ICC-ES AC106.
 - e. Concrete Adhesive Type Anchors: Complying with ICC-ES AC308.
 - f. Other Types: As required.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. AFCON, a brand of Anvil International.
 - b. Powers Fasteners, Inc.
 - c. Hilti.

2.8 MECHANICAL COUPLINGS

- A Couplings for all piping 1-1/2 -in or greater shall be gowned.
- B Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 1. Anvil International.
 2. Shurjoint Piping Products, Inc.
 3. Tyco Fire Protection Products.
 4. Victaulic Company.
- C Rigid Mechanical Couplings for Grooved Joints:
 1. Dimensions and Testing: Comply with AWWA C606.
 2. Minimum Working Pressure: 300 psig (2065 kPa).
 3. Housing Material: Fabricate of ductile iron complying with ASTM A536.
 4. Housing Coating: Factory applied .
 5. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F (minus 34 degrees C) to 230 degrees F (110 degrees C).
 6. Bolts and Nuts: Hot-dipped-galvanized or zinc-electroplated steel.
 7. Provide stops for direct stab installation without field assembly.

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2.9 PRESSURE GAUGES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. AGF Manufacturing.
 - 2. Dwyer Instruments, Inc.
 - 3. Moeller Instrument Company, Inc.
 - 4. Omega Engineering, Inc.
 - 5. Winters Instruments.

- 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. Diameter: 4-1/2 inch (115 mm).
 - 3. Mid-Scale Accuracy: One percent.
 - 4. Scale: Display in psi and kPa.
 - 5. Range: 0 psi to 300 psi (operating pressure 175 psi or less) and 0 psi to 600 psi (operating pressure over 175 psi)

2.10 PRESSURE RELIEF VALVES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. AGF Manufacturing.
 - 2. Cla-Val Co.
 - 3. Watts.

- B ANSI Z21.22, AGA certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.

PART 3 EXECUTION

3.1 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.

- C Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

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- A Install sprinkler system and service main piping, hangers, and supports in accordance with NFPA 13.
- B Install standpipe piping, hangers, and supports in accordance with NFPA 14.
- C Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- D Install piping to conserve building space, to not interfere with use of space and other work.
- E Group piping whenever practical at common elevations.
- F Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G 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 (100 mm).
 - 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.
- H Pipe Hangers and Supports:
 - 1. Install hangers to provide minimum 1/2 inch (15 mm) space between finished covering and adjacent work.
 - 2. Place hangers within 12 inches (300 mm) of each horizontal elbow.
 - 3. Use hangers with 1-1/2 inch (40 mm) minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 4. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 5. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- I Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
- J Prepare pipe, fittings, supports, and accessories for finish painting. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welding.
 - 1. Painting of interior fire suppression systems is specified in Division 9.
 - 2. Painting of exterior fire suppression systems is specified in Division 9.

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- K Structural Considerations:
1. Do not penetrate building structural members unless indicated.
 2. Locate flexible expansion loops at or near the building seismic joint.
- L Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
1. Underground Piping: Caulk pipe sleeve watertight with lead and oakum or mechanically expandable chloroprene inserts with bitumen sealed metal components.
 2. Aboveground Piping:
 - a. Pack solid using mineral fiber complying with ASTM C592.
 - b. Fill space with an elastomer caulk to a depth of 0.50 inch (15 mm) where penetrations occur between conditioned and unconditioned spaces.
 3. All Rated Openings: Caulk tight with firestopping material complying with ASTM E814 in accordance with Division 7 to prevent the spread of fire, smoke, and gases.
 4. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.
- M 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 watertight seal.
 6. Install in accordance with manufacturer's recommendations.
- N Escutcheons:
1. Install and firmly attach escutcheons at piping penetrations into finished spaces.
 2. Provide escutcheons on both sides of partitions separating finished areas through which piping passes.
 3. Attach plates at the underside only of suspended ceilings.
- O 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, unions, and couplings for servicing are consistently provided.
- P Die-cut threaded joints with full-cut, standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.

3.3 CLEANING

- A Upon completion of work, clean all parts of the installation.

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- 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 210500

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SECTION 210523
GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Two-piece ball valves with indicators.
- B Iron butterfly valves with indicators.
- C Check valves.
- D Iron OS&Y gate valves.
- E Trim and drain valves.

1.2 RELATED REQUIREMENTS

- A Section 210553 - Identification for Fire Suppression Piping and Equipment.
- B Section 211200 - Fire-Suppression Standpipes.
- C Section 211300 - Fire-Suppression Sprinkler Systems.
- D Section 284600 - Fire Detection and Alarm.

1.3 ABBREVIATIONS AND ACRONYMS

- A EPDM: Ethylene-propylene diene monomer.
- B OS&Y: Outside screw and yoke.
- C PTFE: Polytetrafluoroethylene.

1.4 REFERENCE STANDARDS

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- 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 B16.42 - Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300; 2021.
- D 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.
- E AWWA C550 - Protective Interior Coatings for Valves and Hydrants; 2024.
- F AWWA C606 - Grooved and Shouldered Joints; 2022.
- G FM (AG) - FM Approval Guide; Current Edition.
- H FM 1112 - Examination Standard for Indicating Valves (Butterfly or Ball Type); 2020.
- I FM 1120/1130 - Approval Standard for Fire Service Water Control Valves (OS&Y and NRS Gate Valves); 1997.
- J FM 1140 - Approval Standard for Quick Opening Valves 1/4 Inch through 2 Inch Nominal Size; 1998.
- K FM 1210 - Approval Standard for Swing Check Valves; 2004.
- L UL (DIR) - Online Certifications Directory; Current Edition.
- M UL 258 - Shutoff Valves for Trim and Drain Purposes for Fire Protection Service; Current Edition, Including All Revisions.
- N UL 262 - Gate Valves for Fire-Protection Service; Current Edition, Including All Revisions.
- O UL 312 - Check Valves for Fire-Protection Service; Current Edition, Including All Revisions.
- P UL 1091 - Standard for Butterfly Valves for Fire-Protection Service; Current Edition, Including All Revisions.

1.5 ADMINISTRATIVE REQUIREMENTS

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- A Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.6 SUBMITTALS

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

1.7 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with at least than three years of documented experience.
- B Installer Qualifications: Company specializing in performing work of type specified and with at least five years of documented experience.
- C Where listed products are specified, provide products listed, certified, and labeled by FM (AG) as suitable for purpose indicated.
- D Welding Materials and Procedures: Comply with ASME BPVC-IX.

1.8 DELIVERY, STORAGE, AND HANDLING

- A Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect valve ends and flange faces.
 - 3. Set valves open to minimize exposure of functional surfaces.
- 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 and maintain at higher than ambient dew point temperature.
 - b. If outdoor storage is unavoidable, store valves off the ground in watertight enclosures.

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- C Use the following precautions for handling:
 - 1. Use sling to handle large valves, rig to avoid damage to exposed parts.
 - 2. Do not use operating handles or stems as lifting or rigging points.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A Source Limitations: Furnish valves of same kind by same manufacturer.
- B Valve-End Connections:
 - 1. Flanges on Iron Valves: ASME B16.1 or ASME B16.42.
 - 2. Threaded Ends: ASME B1.20.1.
 - 3. Grooved Ends: AWWA C606.
- C Valve Pressure Ratings: Not less than 175 psi or higher as required.
- D Valve Sizes: Same as upstream piping unless otherwise indicated.
- E Valve Actuator Types:
 - 1. Worm-gear actuator with handwheel for quarter-turn valves, except trim and drain valves.
 - 2. Handwheel: For other than quarter-turn trim and drain valves.
 - 3. Hand-lever: For quarter-turn trim and drain valves 2 NPS (50 DN) and smaller.

2.2 TWO PIECE BALL VALVES WITH INDICATORS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Nibco Inc. C
 - 2. FNW.
 - 3. Ames Fire & Waterworks; A WATTS Brand..
 - 4. Victaulic Company..
- B UL 1091 and FM 1112 listed.
- C Description:
 - 1. Minimum Pressure Rating: 175 psig (1200 kPa).
 - 2. Body Design: Two piece.
 - 3. Body Material: Forged brass or bronze.
 - 4. Port Size: Full or standard.
 - 5. Seat: PTFE.

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6. Stem: Bronze or stainless steel.
7. Ball: Chrome-plated brass.
8. Actuator: Worm gear or traveling nut.
9. Supervisory Switch: Internal or external.
10. End Connections: Threaded or grooved.

2.3 IRON BUTTERFLY VALVES WITH INDICATORS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Victaulic Company.
 2. FNW.
 3. Kennedy Valve.
 4. Arita Valve, a Unimech brand.
 5. ALEUM USA..
 6. Fivalco Inc.
 7. Globe Fire Sprinkler Corporation.
 8. Nibco Inc.
- B UL 1091 and FM 1112 listed.
- C Minimum Pressure Rating: 175 psig (1200 kPa).
- D Body Material: Cast or ductile iron.
- E Seat: EPDM.
- F Stem: Stainless steel.
- G Disc: Ductile iron with EPDM coating.
- H Actuator: Worm gear or traveling nut.
- I Supervisory Switch: Internal or external.
- J Body Design: Grooved-end or wafer style.

2.4 SWING CHECK VALVES

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- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Nibco Inc.
 - 2. FNW.
 - 3. Kennedy Valve.
 - 4. Arita Valve, a Unimech brand.
 - 5. ALEUM USA..
 - 6. Kennedy Valve Company; a division of McWane, Inc.
 - 7. Reliable Automatic Sprinkler Co., Inc. (The).
- B UL 312 and FM 1210 listed.
- C Minimum Pressure Rating: 175 psig (1200 kPa).
- D Body Material: Cast or ductile iron.
- E Clapper: Bronze, EPDM-coated ductile iron, or stainless steel.
- F Seat: Bronze or EPDM-coated bronze.
- G End Connections: Grooved or flanged.

2.5 IRON OS&Y GATE VALVES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Nibco Inc.
 - 2. FNW.
 - 3. Kennedy Valve.
 - 4. Arita Valve, a Unimech brand.
 - 5. Reliable Automatic Sprinkler Co., Inc. (The)..
- B UL 262 and FM 1120/1130 listed.
- C Minimum Pressure Rating: 175 psig (1200 kPa).
- D Body and Bonnet Material: Cast or ductile iron.
- E Wedge: Cast or ductile iron, or bronze with elastomeric coating.

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F Stem: Brass, bronze, or stainless steel.

G Packing: Non-asbestos PTFE.

H Supervisory Switch: External.

I End Connections: Grooved or flanged.

2.6 TRIM AND DRAIN VALVES

A Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Nibco Inc. .
 - b. Kennedy Valve Company; a division of McWane, Inc..
 - c. Reliable Automatic Sprinkler Co., Inc. (The)..
2. Description:
 - a. UL 258 or FM 1140 listed.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Design: Two piece.
 - d. Body Material: Forged brass or bronze.
 - e. Port Size: Full or standard.
 - f. Seat: PTFE.
 - g. Stem: Bronze or stainless steel.
 - h. Ball: Chrome-plated brass.
 - i. Actuator: Hand-lever.
 - j. End Connections: Threaded or grooved.

B Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Nibco Inc..
 - b. Kennedy Valve Company; a division of McWane, Inc..
 - c. Reliable Automatic Sprinkler Co., Inc. (The)..
2. Description:
 - a. UL 258 or FM 1140 listed.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Brass or bronze.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

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C Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Nibco Inc. .
 - b. Kennedy Valve Company; a division of McWane, Inc..
2. Description:
 - a. UL 258 or FM 1140 listed.
 - b. Pressure Rating: 175 psig (1200 kPa).
 - c. Body Material: Bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc Holder and Nut: Bronze.
 - g. Disc Seat: Nitrile.
 - h. Packing: Asbestos free.
 - i. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 EXECUTION

3.1 EXAMINATION

- A Confirm valve interior to be free of foreign matter and corrosion.
- B Remove packing materials.
- C Examine guides and seats by operating valves from the fully open position to the fully closed position.
- D Examine valve threads and mating pipe for form and cleanliness.
- E Examine mating flange faces for conditions that might cause leakage.
 1. Check bolting for proper size, length, and material.
 2. Verify gasket for size, defects, damage, and suitable material composition for service.
- F Replace defective valves with new valves.

3.2 INSTALLATION

- A Install valves in accessible locations to allow for operation, inspections, tests, and maintenance.
- B Install listed valves in accordance with their listing.

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- C Install valves in accordance with manufacturer's instructions.
- D Support valves independently of adjacent piping.
- E Install valves in horizontal piping with stem at or above pipe center.
- F Position valves to allow full actuator movement.
- G Install OS&Y valves with full clearance for rising stem. Install surrounding components so they do not interfere with nor are they impacted by full extension of rising stem.
- H Install supervised shutoff valves in supervised-open position.
- I Install permanent identification signs indicating portion of system controlled by each shutoff valve.
- J Install threaded-end valves with unions upstream and downstream.
- K Install valve tags. See Division 21 210553. Label valves in accordance with NFPA standard applying to the piping system in which valves are installed.

END OF SECTION 210523

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SECTION 210553
IDENTIFICATION FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Nameplates.
- B Tags.
- C Pipe markers.
- D Ceiling tacks.

1.2 REFERENCE STANDARDS

- A ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.
- B ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2017.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A Automatic Controls: Tags.
- B Control Panels: Nameplates.
- C Instrumentation: Tags.
- D Major Control Components: Nameplates.
- E Piping: Pipe markers.
- F Pumps: Nameplates.

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G Relays: Tags.

H Small-sized Equipment: Tags.

I Thermostats: Nameplates.

J Valves: Nameplates and ceiling tacks where above lay-in ceilings.

2.2 NAMEPLATES

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Brimar Industries, Inc.
2. Kolbi Pipe Marker Co.
3. Seton Identification Products, a Tricor Direct Company.

B Description: Laminated three-layer plastic with engraved letters.

1. Letter Color: White.
2. Letter Height: 1/4 inch (6 mm).
3. Background Color: Red.
4. Thickness: 1/8 inch (3 mm).
5. Plastic: Comply with ASTM D709.

2.3 TAGS

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Advanced Graphic Engraving, LLC.
2. Brady Corporation.
3. Brimar Industries, Inc.
4. Craftmark Pipe Markers.
5. Kolbi Pipe Marker Co.
6. Seton Identification Products, a Tricor Direct Company.

B Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch (40 mm) diameter.

C Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.4 PIPE MARKERS

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- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Craftmark Pipe Markers.
 - 4. Kolbi Pipe Marker Co.
 - 5. Seton Identification Products, a Tricor Company.
- B 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.
- C Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.
- D Color code as follows:
 - 1. Fire Quenching Fluids: Red with white letters.

2.5 CEILING TACKS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Craftmark Pipe Markers.
- B Description: Steel with 3/4 inch (20 mm) diameter color coded head.
- C Color code as follows:
 - 1. Piping: White with black letters.
 - 2. Sprinkler Valves: White with black letters.

PART 3 EXECUTION

3.1 PREPARATION

- A Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

- A Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

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- 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 (20 mm) diameter and smaller.
 - 1. Identify service, flow direction, and indicate high pressure if above 175 psi.
 - 2. Install in clear view and align with axis of piping.
 - 3. Locate identification not to exceed 20 feet (6 m) 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 Locate ceiling tacks to locate valves above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 210553

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SECTION 210800

COMMISSIONING OF FIRE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.
- B. Division 01 section 'LEED Requirements' for additional LEED requirements.

1.2 SUMMARY

- A. This section includes commissioning process requirements for Fire Suppression systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. O&M manuals

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- F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the fire protection contractor of Division 21 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 21. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

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PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional/Functional Checklists for all commissioned components, equipment, and systems
- B. **Red-lined Drawings:** The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. **Operation and Maintenance Data:** Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.
- D. **Demonstration and Training:** Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend construction phase coordination meetings.
- D. Participate in Fire Suppression systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- G. Prepare preliminary schedule for Fire Suppression system orientations and inspections, operation and maintenance manual submissions, training sessions, flushing and cleaning, equipment start-up, and task completion for owner. Distribute preliminary schedule to commissioning team members.
- H. Update schedule as required throughout the construction period.
- I. Assist the CxA in all verification and functional performance tests.

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- J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- M. Participate in, and schedule vendors and contractors to participate in the training sessions.
- N. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Fire Suppression equipment including pumps, piping, and all other equipment furnished under this Division.
 - 2. Automatic sprinkler system.
- O. The equipment supplier shall document the performance of his equipment.
- P. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- Q. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- R. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

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3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that Fire Suppression systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Fire Suppression instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Inspect and verify the position of each device and interlock identified on checklists.
- E. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- F. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Fire Protection testing shall include entire Fire Suppression installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions.
- D. The CxA along with the Fire Suppression contractor shall prepare detailed testing plans, procedures, and checklists for Fire Suppression systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the Fire Suppression system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

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- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.
- 3.8 FIRE SUPPRESSION SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES
- A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 21 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
 - B. **Fire Suppression Distribution System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of sprinkler distribution systems.
 - C. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
 - 1. Fire Protection Piping
 - 2. Fire and Jockey Pump
- 3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT
- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.
- 3.10 APPROVAL
- A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.
- 3.11 DEFERRED TESTING
- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.
- 3.12 OPERATION AND MAINTENANCE MANUALS
- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
 - B. Refer to Division 01 Section "General Commissioning Requirements" for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.
- 3.13 TRAINING OF OWNER PERSONNEL
- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to training.

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END OF SECTION 210800

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SECTION 211200
FIRE-SUPPRESSION STANDPIPES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Fire hose cabinets.
- B Valves.
- C Fire department connections.

1.2 RELATED REQUIREMENTS

- A Division 01 - Administrative Requirements: Submittal procedures, project meetings, progress schedules and documentation, reports, coordination.
- B Division 01 - Regulatory Requirements.
- C Division 01 - Product Requirements: Fundamental product requirements, substitutions and product options, delivery, storage, and handling.
- D Division 01 - Closeout Submittals: Project record documents, operation and maintenance (O&M) data, warranties and bonds.
- E Section 210500 - Common Work Results for Fire Suppression.
- F Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- G Section 210553 - Identification for Fire Suppression Piping and Equipment.
- H Section 211300 - Fire-Suppression Sprinkler Systems.
- I Section 213000 - Fire Pumps.

1.3 REFERENCE STANDARDS

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- A ASTM A536 - Standard Specification for Ductile Iron Castings; 1984, with Editorial Revision (2019).
- B ASTM B61 - Standard Specification for Steam or Valve Bronze Castings; 2015 (Reapproved 2021).
- C FM (AG) - FM Approval Guide; Current Edition.
- D NFPA 14 - Standard for the Installation of Standpipe and Hose Systems; 2024.
- E NFPA 1963 - Standard for Fire Hose Connections; 2019.
- F UL 405 - Standard for Safety Fire Department Connection Devices; Current Edition, Including All Revisions.
- G UL (DIR) - Online Certifications Directory; Current Edition.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Preinstallation Meeting: Conduct a preinstallation meeting at least one week prior to the start of the work of this section; require attendance by all affected installers.

1.5 SUBMITTALS

- A Division 01 - Administrative Requirements for submittal procedures.
- B Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C Shop Drawings:
 - 1. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components, and accessories. Indicate system controls.
 - 2. Submit engineer of record approved shop drawings, product data, and hydraulic calculations to Authorities Having Jurisdiction for approval.
 - 3. Submit shop drawings and product data to Owner's insurance underwriter for approval.
 - 4. Submit proof of approval to Architect.
- D Project Record Documents: Record actual locations of components and deviations of piping from drawings.

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- E Operation Data: Include appropriate manufacturer's data.
- F Maintenance Data: Include servicing requirements and test schedule.
- G Certificates: Provide certificate of compliance from authority having jurisdiction indicating approval of field acceptance tests.
- H Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Division 01 - Product Requirements for additional provisions.

1.6 QUALITY ASSURANCE

- A Perform Work in accordance with NFPA 14.
- B Installer Qualifications: Company specializing in performing the work of this section with documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A Deliver and store products in shipping packaging until installation.

1.8 WARRANTY

- A See Division 01 - Closeout Submittals for additional warranty requirements.
- B Correct defective Work within a one year period after Date of Substantial Completion.
- C Provide one year manufacturer warranty.

PART 2 PRODUCTS

2.1 FIRE VALVE CABINETS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Ansul, a Tyco Business.
 - 2. Potter Roemer Fire Pro.
 - 3. Fire End & Croker Corporation.
- B Cabinet:

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1. Style: Recessed mounted.
2. Tub: 16 gauge, 0.0598 inch (1.52 mm) thick steel, prepared for pipe and accessory rough-in.
3. Door: 12 gauge, 0.1046 inch (2.66 mm) thick steel, flush, glazed with 1/4 inch (6.35 mm) thick wired glass full panel; hinged, positive latch device.
4. Finish: Enameled, color as indicated by the architect.
5. Fire Rating: The fire hose cabinet shall have a fire rating equivalent to the fire rating of the wall in which it is installed.

2.2 VALVES

A Specialty Valves:

1. Hose Connection Valve:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) Zurn Industries, LLC.
 - 2) Elkhart Brass
 - b. Angle type; brass finish; 2-1/2 inch NPS (65 mm, DN), thread to match fire department hardware, 300 psi (2,070 kPa) working pressure, with threaded cap and chain of same material and finish.
2. Pressure Reducing Valve:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) Viking Corporation.
 - 2) Tyco Fire Protection Products.
 - 3) Victaulic Company.
 - 4) Zurn Industries, LLC.
 - 5) Elkhart Brass.
 - b. Straight away type; brass finish with inner hydraulic controls; 2-1/2 inch (65 mm, DN) size, thread to match fire department hardware, 400 psi (2,760 kPa) inlet pressure, with threaded cap and chain of same material and finish.
 - c. Function: Reduce high inlet pressure down to an adjustable preset output maintained independent of flow rate fluctuations.
3. Pilot Operated Control Valves:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) Viking Corporation.
 - 2) Tyco Fire Protection Products.
 - 3) Victaulic Company.
 - 4) Zurn Industries, LLC.
 - 5) Elkhart Brass.
 - 6) _____.
 - b. Size: 1-1/2 to 8 inch, NPS (40 to 200 mm, DN), flanged or grooved end-connections.
 - c. Type: Field adjustable in-line valve rated for 400 psi (2,760 kPa) inlet pressure with outlet discharge field-set to system pressure.

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- d. Construction:
 - 1) Body: ASTM A536, ductile iron, grade 65-45-12.
 - 2) Internal Ferrous Materials: Coated with 4 mils, 0.004 inch (0.10 mm) of epoxy.
 - 3) External Surface Coating: 4 mils, 0.004 inch (0.10 mm) of epoxy and fire red enamel.
 - 4) Main Valve Seat Ring: ASTM B61, bronze.
 - 5) Stem: Stainless Steel.
 - 6) Elastomers for Diaphragms, Resilient seats, and O-rings: Buna-N.
 - 7) Pilot Control: ASTM B61, bronze with stainless steel trim and pressure gages.
- 4. Angle Hose Valves:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) Zurn Industries, LLC.
 - 2) Elkhart Brass.
 - b. Cast bronze, 2-1/2 inch, NPS (65 mm, DN) handwheel operated globe valve with grooved or threaded end connections, rated for 400 psi (2,760 kPa) inlet pressure with outlet discharge field-set to hose inlet pressure.
- 5. In-line or Angle Floor Control Valves:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) Zurn Industries, LLC.
 - 2) Elkhart Brass.
 - b. Cast bronze, 2-1/2 inch, NPS (65 mm, DN) handwheel operated globe valve with grooved or threaded end connections, rated for 400 psi (2,760 kPa) maximum inlet pressure with outlet discharge field-set to system inlet pressure. Provide integral normally-open supervisory switch, cap, and chain.

2.3 FIRE DEPARTMENT CONNECTIONS

- A Type: Free standing and flush mount made of corrosion resistant metal complying with UL 405.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Elkhart Brass Manufacturing Company, Inc.
 - b. Fire End & Croker Corporation.
 - c. _____.
 - 2. Inlets: Three-way, 2-1/2 inch (65 mm, DN) swivel fittings, internal threaded. Thread size and inlets according to or Authority Having Jurisdiction- Detroit Standard Threads. Brass caps with gaskets, chains, and lugs.
 - 3. Configuration: Horizontal.
 - 4. Outlet: Bottom with pipe threads, 6 inch NPS (150 mm, DN).
 - a. Location: Back.
 - 5. Rated Working Pressure: 175 psi (1200 kPa).
 - 6. Finish: Chrome.
 - 7. Sleeve: Brass, 18 inches (460 mm) height.
 - 8. Signage: Raised or engraved lettering 1 inch (25.4 mm) minimum indicating system type.

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PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install in accordance with NFPA 14.
- C Locate and secure cabinets plumb and level. Establish top of cabinet (inside horizontal) surface 66 inches (1675 mm) above finished floor.
- D Locate hose station valve at 48 inches above finished floor.
- E Connect standpipe system to water source ahead of domestic water connection.
- F Where static pressure exceeds 175 psi at any hose station, provide pressure reducing valve.
- G Provide fire department outlet connection on roof.
- H Flush entire system of foreign matter.

3.2 FIELD QUALITY CONTROL

- A Perform field inspection and testing (Field Acceptance Test) in accordance with Division 01.
- B Test entire system in accordance with NFPA 14.
- C Test shall be witnessed by Fire Marshal.

END OF SECTION 211200

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SECTION 211300
FIRE-SUPPRESSION SPRINKLER SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Wet-pipe sprinkler system.
- B System design, installation, and certification.
- C Fire department connections.

1.2 RELATED REQUIREMENTS

- A Division 07 - Firestopping.
- B Section 210500 - Common Work Results for Fire Suppression: Pipe and fittings.
- C Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- D Section 210553 - Identification for Fire Suppression Piping and Equipment.
- E Section 211200 - Fire-Suppression Standpipes.
- F Section 213000 - Fire Pumps.
- G Section 284600 - Fire Detection and Alarm.

1.3 REFERENCE STANDARDS

- A FM (AG) - FM Approval Guide; Current Edition.
- B ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements; 2018, with Editorial Revision (2020).
- C ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry; 2018, with Editorial Revision (2020).

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- D ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements; 2017, with Editorial Revision (2020).
- E ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements; 2023.
- F NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G NFPA 1963 - Standard for Fire Hose Connections; 2019.
- H UL (DIR) - Online Certifications Directory; Current Edition.
- I UL 405 - Standard for Safety Fire Department Connection Devices; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Preinstallation Meeting: Convene at least one week before starting work of this section.

1.5 SUBMITTALS

- A Division 01 - Administrative Requirements for submittal procedures.
- B Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C Shop Drawings:
 - 1. Include plans, elevations, sections, details, and attachments to other work. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components, and accessories. Indicate system controls.
 - a. Wiring Diagrams: For power, signal, and control wiring.
 - 2. Submit engineer approved shop drawings, product data, and hydraulic calculations to Authorities Having Jurisdiction for approval. Submit proof of approval to Architect before beginning installation.
 - 3. Submit shop drawings and product data to Owner's insurance underwriter (FM) for approval.
- D Manufacturer's Certificate: Certify that system has been tested and meets or exceeds specified requirements and code requirements.

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- E Designer's qualification statement.
- F Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.
- G Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Division 01 Product Requirements or additional provisions.
 - 2. Extra Sprinklers: Type and size matching those installed in quantity required by referenced NFPA design and installation standard.
 - 3. Sprinkler Wrenches: For each sprinkler type.
- H Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.

1.6 QUALITY ASSURANCE

- A Maintain one copy of referenced design and installation standard on site.
- B Comply with FM (AG) requirements.
- C Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.
- D Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- E Installer Qualifications: Company specializing in performing the work of this section documented experience.
- F Equipment and Components: Provide products that bear FM (AG) label or marking.
- G Products Requiring Electrical Connection: Listed and classified by FM (AG) as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A Store products in shipping containers and maintain in place until installation. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

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PART 2 PRODUCTS

2.1 SPRINKLER SYSTEM

- A Sprinkler System: Provide coverage for entire building.
- B Occupancy:
 - 1. Hazard Category 1 (HC-1); Comply with FM Data Sheets and NFPA 13
 - 2. Hazard Category 2 (HC-2); Comply with FM Data Sheets and NFPA 13
 - 3. Hazard Category 3 (HC-3); Comply with FM Data Sheets and NFPA 13
- C Water Supply: Determine volume and pressure from water flow test data.
 - 1. Fire sprinkler contractor shall provide an up-to-date flow test during the shop drawing preparation.
- D Interface system with building fire and smoke alarm system.
- E Provide fire department connections where indicated.
- F Storage Cabinet for Spare Sprinklers and Tools: Steel, located adjacent to alarm valve.

2.2 SPRINKLERS

- A Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Tyco Fire Products
 - b. Viking Corporation
 - c. Victaulic Company
 - d. Reliable
- B Suspended Ceiling Type: Concealed pendant type with matching push on cover plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Finish: White.
 - 4. Escutcheon Plate Finish: White.
 - 5. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- C Exposed Area Type: Upright type.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.

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3. Finish: Brass.
 4. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- D Sidewall Type: Concealed horizontal sidewall type with matching push on escutcheon plate.
1. Response Type: Quick.
 2. Coverage Type: Standard.
 3. Finish: Enamel, color white .
 4. Escutcheon Plate Finish: Enamel, color white .
 5. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- E Dry Sprinklers: Concealed pendant and sidewall type with matching push on escutcheon plate as indicated on drawings.
1. Response Type: Quick.
 2. Coverage Type: Standard.
 3. Finish: Brass.
 4. Cover Plate Finish: White.
 5. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- F Window Sprinklers: Concealed pendant vertical sidewall type with matching push on escutcheon plate as indicated on the drawings:
1. Not to be used with horizontal mullions.
 2. Provides a two-hour equivalency for a fire separation assembly when acceptable to the AHJ.
 3. Installed in strict accordance with the manufacturers' installation instructions and technical data sheet.
- G Guards: Finish to match sprinkler finish. UL listed wire guards.
- H Flexible Drop System: Stainless steel, multiple use, open gate type.
1. Application: Use to properly locate sprinkler heads.
 2. Include all supports and bracing.
 3. Provide braided type tube as required for the application.
 4. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. FlexHead Industries, a brand of Anvil International:
 - b. Victaulic Company.

2.3 PIPING SPECIALTIES

- A Wet Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber-faced clapper to automatically actuate water motor alarm, pressure retard chamber and variable pressure trim with the following additional capabilities and features:
1. Activate electric alarm.
 2. Test and drain valve.

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3. Replaceable internal components without removing valve from installed position.
 4. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Victaulic Company.
 - b. Viking Corporation.
- B Backflow Preventer: Double check valve assembly backflow preventer with drain and OS&Y gate valve on each end.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Ames Fire & Waterworks.
 - b. Watts.
 - c. Zurn Wilkins
- C Test Connections:
1. Inspector's Test Connection for Dry Systems:
 - a. Provide test connections for each sprinkler system equipped with an alarm device, located at the most remote part of each system.
 - b. Route test connection to an open-site drain location, excluding janitor sinks, accepting full flow without negative consequences.
 - c. Supply discharge orifice with same size as corresponding sprinkler orifice.
 - d. Limit vertical height of exterior wall penetration to 2 ft (0.61 m) above finished grade.
 2. Backflow Preventer Test Connection:
 - a. Provide downstream of the backflow prevention assembly, listed hose valves with 2.5 inch (65 mm) National Standard male hose threads with cap and chain.
 - b. Furnish one valve for each 250 gpm (16 L/s) of system demand or fraction thereof.
 - c. Provide permanent sign reading "Test Valve" in accordance with Section 210553.
- D Electric Alarm: Electrically operated notification device. Device shall be weather-proof.
- E Pressure Switch: Pressure type for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.5 amp at 24 volt DC.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Potter Electric Signal Company, LLC.
- F Air Supervisory Switch: Pressure type for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.5 amp at 24 volt DC.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Potter Electric Signal Company, LLC.
- G Water Flow Switch: Vane type switch for mounting horizontal or vertical, with two contacts; rated 10 amp at 125 volt AC and 2.5 amp at 24 volt DC.

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1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Potter Electric Signal Company, LLC.

H Fire Department Connections: See Section 211200 Fire-Suppression Standpipes.

I Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Potter Electric Signal Company, LLC.
 - b. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - c. Kennedy Valve Company; a division of McWane, Inc.

2.4 AUTOMATIC AIR VENT

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. AGF Manufacturing, Inc.
 2. CLA-VAL.
 3. Engineered Corrosion Solutions.
 4. Metraflex Company (The).
 5. Val-Matic Valve & Manufacturing Corp.
- B Description: Automatic air vent that automatically vents trapped air without human intervention and closes when water reaches the vent.
- C Standard: UL listed or FM Global approved for use in wet-pipe fire sprinkler systems.
- D Body Material: Stainless steel with a 1/2-inch stainless steel screen with inspection port.
- E Minimum Water Working Pressure Rating: 175 psig.
- F Connection: 1/2 inch NPT female inlet connection and a 1/2-inch NPT male outlet connection.

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with referenced NFPA design and installation standard.
- B Install equipment in accordance with manufacturer's instructions.

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- C Provide approved double check valve assembly at sprinkler system water source connection.
- D Locate fire department connection with sufficient clearance from walls, obstructions, or adjacent connectors to allow full swing of fire department wrench handle.
- E Locate outside electric alarm device on building wall as indicated.
- F Place pipe runs to minimize obstruction to other work.
- G Place piping in concealed spaces above finished ceilings.
- H Center sprinklers in two directions in ceiling tile and provide piping offsets as required.
- I Apply masking tape or paper cover to ensure concealed sprinklers, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting. Replace painted sprinklers.
- J Install and connect to fire pump system in accordance with Section 213000.
- K Flush entire piping system of foreign matter.
- L Install guards on sprinklers that are subject to mechanical damage..
- M Hydrostatically test entire system.
- N Require test be witnessed by Authority Having Jurisdiction.

3.2 INTERFACE WITH OTHER PRODUCTS

- A Ensure required devices are installed and connected as required to fire alarm system.

END OF SECTION 211300

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SECTION 213000
FIRE PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Split-case fire pump.
- B Electric motor drive.
- C Jockey pump.

1.2 RELATED REQUIREMENTS

- A Section 210500 - Common Work Results for Fire Suppression: Fire protection piping.
- B Section 284600 - Fire Detection and Alarm.

1.3 REFERENCE STANDARDS

- A FM (AG) - FM Approval Guide; Current Edition.
- B NEMA MG 00001 - Motors and Generators; 2024.
- C NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- D NFPA 13 - Standard for the Installation of Sprinkler Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E NFPA 20 - Standard for the Installation of Stationary Pumps for Fire Protection; 2025.
- F UL (DIR) - Online Certifications Directory; Current Edition.
- G UL 448 - Centrifugal Stationary Pumps for Fire-Protection Service; Current Edition, Including All Revisions.
- H UL 1478 - Fire Pump Relief Valves; Current Edition, Including All Revisions.

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1.4 ADMINISTRATIVE REQUIREMENTS

- A Preinstallation Meeting: Convene at least one week before starting work of this section.

1.5 SUBMITTALS

- A See Division 01 - Administrative Requirements for submittal procedures.
- B Product Data: Provide manufacturers literature including general assembly, pump curves showing performance characteristics with pump and system, operating point indicated, NPSH curve, controls, valves, wiring diagrams, service connections, and any other associated equipment.
- C Shop Drawings: Indicate layout, general assembly, components, dimensions, weights, clearances, and methods of assembly.
- D Certificates: Certify that fire pumps meet or exceed specified requirements at specified operating conditions and that the installation complies with regulatory requirements. Submit summary and results of shop tests performed in accordance with NFPA 20
- E Test Reports: Indicate results of hydrostatic test and field acceptance tests.
- F Manufacturer's Instructions: Indicate support details, connection requirements, for fire pump system.
- G Operation Data: Include manufacturers instructions, start-up data, trouble-shooting check lists, for pumps, drivers, and controllers.
- H Maintenance Data: Include manufacturers literature, cleaning procedures, replacement parts lists, and repair data for pumps, drivers and controllers.
- I Project Record Documents: Record actual locations of components and accessories.
- J Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Division 01 - Product Requirements for additional provisions.
 - 2. Extra Pump Gaskets/Screens/Seals: One set for each different pump model.

1.6 QUALITY ASSURANCE

- A Comply with NFPA 13 and NFPA 20; where requirements differ comply with the most stringent.

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- B Maintain on site at all times one copy of each design and installation standard referenced.
- C Design fire pump system under direct supervision of a Professional Engineer experienced in design of this work and licensed at the State in which the Project is located.
- D Equipment and Components: Bearing FM (AG) label or marking.
- E Products Requiring Electrical Connection: Listed and classified by FM (AG) as suitable for the purpose specified and indicated.
- F Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- G Installer Qualifications: Company specializing in performing the work of this section with documented experience and approved by the manufacturer.
- H Provide certificate of compliance from authority have jurisdiction indicating approval of field acceptance tests.

1.7 DELIVERY, STORAGE, AND HANDLING

- A Deliver fire pumps and components in factory packing. Comply with manufacturer's rigging and installation instructions.
- B Protect fire pumps and components from physical damage including effects of weather, water, and construction debris.
- C Provide temporary inlet and outlet caps, and maintain in place until installation.

PART 2 PRODUCTS

2.1 FIRE PUMPS

- A Split-Case Fire Pump:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. AC Fire Pump, a Xylem brand.
 - b. Aurora, a Pentair brand.
 - c. Fairbanks Nijhuis, a Pentair brand.
 - d. Patterson Pump Company, a Gorman-Rupp Company.
 - e. SPP Pumps, Inc.
 - f. SyncroFlo, Inc.

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- g. Peerless Pump Company.
- 2. UL 448 and UL 778; vertical- or horizontal-mounted, single-stage, double-suction centrifugal pump for maximum working pressure of 294 psi (2,027 kPa).
- 3. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- 4. Impeller: Bronze double suction fully enclosed, balanced and keyed to shaft.
- 5. Bearings: Grease lubricated ball bearings, replaceable without opening casing.
- 6. Shaft: Alloy steel with replaceable bronze shaft sleeve.
- 7. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 230 degrees F (110 degrees C) maximum continuous operating temperature.
- 8. Drive: Flexible coupling with coupling guard.
- 9. Baseplate: Cast iron or fabricated steel with integral drain rim.
- 10. Performance:
 - a. Capacity: 750 gpm at 140 psi.
 - b. Electric Motor Drive: 100 hp, 480 VAC, three phase, 60 Hz.

B Accessories:

- 1. Eccentric suction reducer and OS&Y gate or butterfly valve on suction side of pump.
- 2. Concentric increaser and check valve in pump discharge and OS&Y gate or butterfly valve on system side of check valve.
- 3. Fire pump bypass fitted with OS&Y gate or butterfly valves and check valve.
- 4. Main relief valve, UL 1478 and enclosed type waste cone.
- 5. Suction pressure gauge, 4-1/2 inch (110 mm) diameter dial with snubber, valve cock and lever handle.
- 6. Discharge pressure gauge mounted on board attached to pump, with snubber, valve cock and lever handle.
- 7. 3/4 inch (20 mm) casing relief valve.
- 8. Float operated 3/4 inch (20 mm) automatic air release valve.
- 9. Hose valve manifold with 2-1/2 inch (65 mm) hose gate valves with caps and chains.

2.2 ELECTRIC MOTOR DRIVE:

- A Motor: Squirrel cage induction type, NEMA MG 00001; in open drip-proof NEMA EN 10250 enclosure, 1,785 rpm.

2.3 FULL-SERVICE CONTROLLERS

2.4 GENERAL REQUIREMENTS FOR FULL-SERVICE CONTROLLERS:

- 1. Comply with NFPA 20 and UL 218.
- 2. Combined automatic and nonautomatic operation.
- 3. Factory assembled, wired, and tested; continuous-duty rated.

B Method of Starting:

- 1. Pressure-switch actuated.

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- a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - b. System pressure recorder, electric ac driven, with spring backup.
 - c. Programmable minimum-run-time relay to prevent short cycling.
 - d. Programmable timer for weekly tests.
 2. Solid-State Controller: Reduced voltage type.
 3. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contractor independent of electric or pressure actuators.
- C Method of Stopping: Automatic and nonautomatic shutdown after automatic starting.
- D Capacity: Rated for fire pump driver horsepower and short circuit current rating equal to or greater than short circuit current available at controller location.
- E Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.
- F Door Mounted Operator Interface and Controls:
1. Monitor, display, and control the devices; alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 2. Method of Control and Indication:
 - a. Microprocessor-based logic controller, with multiline digital readout.
 - b. Membrane keypad.
 - c. LED alarm and status indicating lights.
 3. Local Alarm and Status Indications:
 - a. Controller power on.
 - b. Motor running condition.
 - c. Loss-of-line power.
 - d. Line-power phase reversal.
 - e. Line-power single-phase condition
 4. Audible alarm, with silence push buttons.
 5. Nonautomatic START and STOP push buttons or switches.
- G ATS:
1. Complies with NFPA 20, UL 218, and UL 1008.
 2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
 3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 4. Allows manual transfer from one source to the other.
 5. Alternate-Source Isolating and Disconnecting Means:
 - a. Integral molded-case switch, with an externally mounted operating handle.
 6. Local Alarm and Status Indications:
 - a. Normal source available.

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- b. Alternate source available.
- c. In normal position.
- d. In alternate position.
- e. Isolating means open.
- 7. Audible alarm, with silence push button.
- 8. Nonautomatic means of transfer.
- 9. Engine test push button.
- 10. Start generator output contacts.
- 11. Timer for weekly generator tests.

2.5 JOCKEY PUMP

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Armstrong Fluid Technology.
 - 2. Aurora, a Pentair brand.
 - 3. Fairbanks Nijhuis, a Pentair brand.
 - 4. Grundfos.
 - 5. Talco Fire Systems.
- B Electrically operated, horizontal or vertical, single or multi stage, turbine type centrifugal pump with standard open drip-proof horizontal motor.
- C Control by automatic jockey pump controller with full voltage starter to start pump on pressure drop in system. Fire pump shall start automatically on further pressure drop or on jockey pump failure.
- D Performance:
 - 1. Capacity: 8 gpm at 150 psi.
 - 2. Electric Motor Drive: 3 hp, 208 VAC, three phase, 60 Hz.

2.6 PRESSURE RELIEF VALVES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. AGF Manufacturing
 - 2. Cla-Val Co
 - 3. Watts
- B ANSI Z12.22, AGA Certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure activated.

PART 3 EXECUTION

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3.1 INSTALLATION

- A Install in accordance with NFPA 20.
- B Provide access space around pumps for service; no less than minimum as recommended by manufacturer.
- C Piping: 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 base mounted pumps, provide supports under elbows on pump suction and discharge; see Section 210500.
- D Provide drains for bases and seals, piped to and discharging into floor drains.
- E Provide for connection to electrical service.
- F Lubricate pumps before start-up.
- G Check, align, and certify pumps by qualified installer prior to start-up.
- H Provide supervisory alarm notifications using auxiliary dry contacts interconnected into fire alarm system for monitoring by Owner-designated central or off-site point of constant attendance.
- I Provide remote monitoring of pump using either auxiliary dry contacts or software data-link into BAS, BMS, SCADA, or other Integrated Automation System; see Section 251500 and 230923 or 251400. Remotely monitored points to include:
 - 1. Run status.
 - 2. Trouble or fault status.
 - 3. Phase reversal status.
 - 4. Supervisory alarm notifications.

3.2 FIELD QUALITY CONTROL

- A See Section Division 01 Quality Requirements for additional requirements.
- B Perform hydrostatic tests, flushing, and field acceptance tests as specified in NFPA 20.
- C Perform field acceptance tests in the presence of Authority Having Jurisdiction.

3.3 CLOSEOUT ACTIVITIES

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- A See Division 01 Closeout Submittals for additional submittals.
- B See Division 01 Demonstration and Training for additional requirements.
- C Demonstrate automatic operation of system including verification of pressure switch set points to Owner.
- D Use operation and maintenance data as reference during demonstration.
- E Briefly describe function, operation, and maintenance of each component.
- F Conduct walking tour of project.
- G 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.
 - 3. Instructor: Manufacturer's training personnel.
 - 4. Location: At project site.

3.4 MAINTENANCE

- A See Division 01 Execution and Closeout Requirements for additional requirements.
- B Provide a separate maintenance contract for specified maintenance service.
- C Perform maintenance using competent personnel in the direct employ of the system installer.
- D Provide service and maintenance of equipment installed under this section for one year from the Date of Substantial Completion.

END OF SECTION 213000

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SECTION 220500
COMMON WORK RESULTS FOR PLUMBING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Escutcheons.
 - 3. Grout.
 - 4. Equipment installation requirements common to equipment sections.
 - 5. Concrete bases.
 - 6. Supports and anchorages.

1.3 DEFINITIONS

- A Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct 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 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 The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene monomer rubber.

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2. NBR: Acrylonitrile-butadiene rubber.

1.4 GENERAL SUBMITTAL REQUIREMENTS

- A Identify each submittal in detail. Note what differences, if any, exist between the submitted item and the specified item. Failure to identify the differences will be considered cause for disapproval. If differences are not identified and are not discovered during the submittal review process, the Contractor remains responsible for providing equipment and materials that meet the Specifications and Drawings.
- B Submittals processed by the Architect/Engineer do not become Contract Documents.
- C The purpose of submittals is to establish a reporting procedure for the Architect/Engineer to monitor the Contractor's compliance with the Contract Documents.
- D If deviations, discrepancies, or conflicts between submittals and the Contract Documents are discovered (before or after processing by the Architect/Engineer), the Contract Documents shall control.

1.5 CODE, REFERENCES AND STANDARDS:

- A Applicable Codes and Standards:
 - 1. Michigan Building Code, 2021
 - 2. Michigan Building Code, 2021
 - 3. International Fuel Gas Code, 2021
 - 4. Michigan Energy Code, 2021
 - 5. ASHRAE Standard 90.1 - 2019
- B The latest editions of the following are hereby included in and made a part of Division 22:
 - 1. NFPA National Fire Protection Association
 - 2. UL Underwriters' Laboratories, Inc.
 - 3. NEMA National Electrical Manufacturer's Association
 - 4. NEC National Electric Code
 - 5. ASME American Society of Mechanical Engineers
 - 6. AWS American Welding Society
 - 7. ANSI American National Standards Institute
 - 8. AGA American Gas Association
 - 9. HI Hydronics Institute
 - 10. OSHA Occupational Safety and Health Act
 - 11. AWWA American Water Works Association
 - 12. CISPI Cast Iron Soil Pipe Institute

1.6 QUALITY ASSURANCE

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- 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 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.

1.7 DELIVERY, STORAGE, AND HANDLING

- A Piping and equipment, and associated accessories kept on-site should be stored off the ground on skids, ends should be capped or sealed, and these items should be covered with plastic to prevent fouling or contact with excessive moisture. Piping and equipment should be cleaned of debris inside and out before installation and should be kept clean and protected throughout construction.
- B Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 COORDINATION

- A Contractor shall coordinate the work of the different trades so that interference between piping, equipment, structural, and electrical work will be avoided. All necessary offsets in piping and all fittings, and other components, required to install the work properly shall be furnished complete in place at no additional cost.
- B Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C It is required that Contractors visit the site of the work and become familiar with the conditions affecting the installation prior to bidding. Submission of a Bid shall presuppose knowledge of such conditions and no additional compensation shall be allowed where extra labor or materials are required because of the lack of knowledge of these conditions.
- D The contractor shall produce full coordination drawings between all trades identifying any areas of interference or clashes prior to the start of construction. Modifications shall be made to the associated systems to resolve the issue in coordination with and approval of the architect and engineer.

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- E Unless otherwise stipulated under a particular heading, the following rules relative to responsibilities of the Contractors and Subcontractors will apply:
1. Make-up water piping connections shall be provided by the Plumbing Contractor to within five (5) feet of the required point of connection to the equipment and there terminated with a shut-off valve. Each trade shall make the final connection to the equipment it installs.
 2. Ceiling access panels will be installed by the General Contractor at locations determined by the Plumbing Contractor.
 3. The Plumbing Contractor or subcontractor shall install all roughing-in pertaining to his trade for each item of equipment furnished under another Section of the Specifications or by the Owner.
 4. The Plumbing Contractor shall make final connections of equipment to rough-ins.

1.9 DESIGN DRAWINGS

- A The Contract Drawings are diagrammatic and are not intended to show exact location of equipment, piping and ductwork unless dimensions are given. Systems and distribution are to be installed along the general plans shown on the Drawings, but in coordination with actual field conditions.
- B Extra costs which might result from deviations from the Drawings, so as to avoid interferences, shall be considered a "Job Condition", and no additional compensation will be considered applicable. In the event that such interferences occur in the course of the Work, due to an error, omission, or oversight by the Contractor, no additional compensation shall be allowed. Interferences which may occur during the course of construction shall be brought to the immediate attention of the Architect/Engineer, and his/her decision, confirmed in writing, shall be final.

1.10 EQUIPMENT START-UP

- A Start-up of all plumbing equipment shall be video-recorded by the plumbing contractor. Two DVD copies shall be turned over to the Owner's maintenance staff.

1.11 TESTING AND REPAIR

- A All piping systems shall be thoroughly cleaned and flushed prior to final testing.
- B Pressure testing shall be completed for the following piping systems:
1. Domestic water, sanitary and vent, storm and gas piping systems, and other systems as noted on the plans.
- C All testing must be witnessed and accurately recorded noting methods of testing, times, dates, and results.

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- D Any damage as a result of tests shall be repaired or damaged materials replaced at no cost to the Owner.

1.12 FINAL COMPLETION

- A All work shall be cleaned prior to issuance of Substantial Completion.
- B Retouch or repaint factory painted prime and finish coats where scratched or damaged.
- C Deliver any equipment as required by this Specification to Owner and obtained signed receipts of delivery.
- D Clean equipment, restore damaged materials, and leave the Work in acceptable condition.
- E Remove all site tools, equipment, surplus materials and rubbish continuously at no additional cost to the Owner.
- F Contractor shall submit written certificates warranting each item of equipment.

PART 2 PRODUCTS

2.1 EQUIPMENT AND MATERIALS:

- A All equipment and materials shall be furnished in strict accordance with the equipment named and according to Specification requirements. Each bid shall be based upon one of the materials or manufacturers specified.
- B Equipment and materials specified shall be considered to have prior approval, but submittal for approval is required. Furnish construction drawings to other Contractors when required to coordinate construction.
- C Where multiple manufacturers are named the drawings and specifications are based on the requirements and layouts for the equipment of the first named manufacturer. Any change required by the use of other named manufacturers such as revisions to foundations, bases, piping, controls, wiring, openings, and appurtenances shall be made by the Contractor at no additional cost to the Owner.

2.2 PIPE, TUBE, AND FITTINGS

- A Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

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- B Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A Refer to individual 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 Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- D Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- E Solder Filler Metals: ASTM B 32, 95/5 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. CPVC Piping: ASTM F 493.
 2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.4 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.

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- C One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- D One-Piece, Cast-Brass Type: With set screw and polished chrome-plated finish
- E Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
- F One-Piece, Floor-Plate Type: Cast-iron floor plate.
- G Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.5 GROUT

- A Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, non-staining, 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 3 EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A Install piping according to the following requirements and Division 23 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 Piping shall not project beyond walls or steel lines nor shall it hang below slabs more than is absolutely necessary. Particular attention shall be paid to the required clearances.

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- F Offset piping where required to avoid interference with other work, to provide greater headroom or clearance, or to conceal pipe more readily. Offsets shall be properly drained or trapped where necessary.
- G Provide swing joints and expansion bends wherever required to allow the piping to expand without undue stress to connections or equipment.
- H Exposed piping around fixtures or in other conspicuous places shall not show tool marks at fittings.
- I Isolate pipe from the building construction to prevent transmission of vibration to the structure and to eliminate noise.
- J Install piping such that any equipment connected to piping may be removed by disconnecting two (2) flanges or unions and removing only one or two pipe sections. All equipment shall have bolted or screwed flanges or unions at pipe connections.
- K Install fittings for changes in direction and branch connections. T-drill system for mechanically formed tee connections and couplings, and Victaulic hole cut piping system are not allowed.
- L Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.
- M Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- N Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- O Install piping to permit valve servicing.
- P Install piping at indicated slopes.
- Q Install piping free of sags and bends.
- R Install piping to allow application of insulation.
- S Eccentric reducing couplings shall be provided in all cases where air or water pockets would otherwise occur due to a reduction in pipe size.
- T Cap and plug all openings in pipes during construction with suitable metal plugs or cap to keep out dirt and rubbish until equipment is connected.

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- U Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- V Select system components with pressure rating equal to or greater than system operating pressure.
- W Install escutcheons for penetrations of walls, ceilings, and floors
- X Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- Y Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- Z 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 annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- AA 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.
- BB Verify final equipment locations for roughing-in.
- CC Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

- A Join pipe and fittings according to the following requirements and Division 23 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.

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- E Brazed Joints: Construct joints according to AWS's "Braze 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. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. 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.

3.3 PIPING CONNECTIONS

- A Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Install dielectric fittings to connect piping materials of dissimilar metals.
- B Unions shall be used in preference to couplings where their use will facilitate dismantling the pipe for maintenance.

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- C Pipe sizes indicated shall be carried full size to equipment served. Any change of size to match equipment connection shall be made within one foot of the equipment. At temperature control valves with sizes smaller than connected lines, reduction shall be made immediately adjacent to valves.

3.4 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.

3.5 CONCRETE BASES

- A Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches (101.6 mm) larger in both directions than supported unit. Install dowel rods to connect concrete base to concrete floor.
 - 2. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete"

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A Refer to Division 05 Section "Metal Fabrications" for structural steel.

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- 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.

3.7 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.

3.8 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 220513
COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 REFERENCE STANDARDS

- A ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015 (Reaffirmed 2020).
- 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.

1.3 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.

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- D Operation Data: Include instructions for safe operating procedures.
- E Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.4 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.

1.5 WARRANTY

- A Provide five year manufacturer warranty for motors larger than 20 horsepower.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Baldor Electric Company/ABB Group
- B Allient (Allied Motion)
- C Regal-Rexnord Corporation (Century, Lesson, Marathon)

2.2 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 (40 degrees C) environment.
 - 3. Comply with IEEE 841 for severe-duty motors.
 - 4. 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.

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- C Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- D 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.

2.3 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 Motors located in exterior locations and explosion proof environments: Totally enclosed type.

2.4 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A Starting Torque: Less than 150 percent of full load torque.
- B Starting Current: Up to seven times full load current.

2.5 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A Starting Torque: Exceeding one fourth of full load torque.
- B Starting Current: Up to six times full load current.
- C Multiple Speed: Through tapped windings.
- D Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector.
- E Motors 1/20 HP and Smaller: Shaded-pole type.

2.6 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A Starting Torque: Three times full load torque.

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- B Starting Current: Less than five times full load current.
- C 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.
- D Drip-proof Enclosure: Class A insulation, NEMA Service Factor, prelubricated sleeve bearings.
- E Enclosed Motors: Class A insulation, 1.0 Service Factor, prelubricated ball bearings.

2.7 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 Design, Construction, Testing, and Performance: Comply with NEMA MG 00001 for Design B motors.
- D Insulation System: NEMA Class F (maximum winding temperature is 155° C) with a Class B allowable temperature rise (allowable temperature rise of 80° C).
- E Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- F 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.
- G Nominal Efficiency: As indicated at full load and rated voltage when tested in accordance with IEEE 112.
- H Nominal Power Factor: As indicated at full load and rated voltage when tested in accordance with IEEE 112.

2.8 MOTORS USED WITH VARIABLE FREQUENCY CONTROLLERS

- A Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.

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- B Inverter-Duty Motors: Class F temperature rise; Class H insulation.
- C Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- D Motor manufacture shall ensure specified motor operational and performance characteristics are suitable for inverter drive operation.
- E Motor shall be provided with minimum of one shaft mounted grounding protection ring to discharge pulse width modulation induced shaft voltages and bearing currents in reducing the effects of bearing pitting and scoring.

2.9 ELECTRONICALLY COMMUTATED MOTORS (ECM)

- A Three-phase power motor module with permanent magnet rotor.
- B Building Automation System interface.

END OF SECTION 220513

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SECTION 220517
SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 RELATED REQUIREMENTS

1.3 REFERENCE STANDARDS

- A ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2022a.
- B ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2023a.

1.4 SUBMITTALS

- A 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.

1.5 DELIVERY, STORAGE, AND HANDLING

- A Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

PART 2 PRODUCTS

2.1 PIPE SLEEVES

- A Manufacturers:
 - 1. Flexicraft Industries
- B Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.

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- C Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
- D Sheet Metal Sleeves: ASTM A653/A653M, 24 gauge minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.
- E Vertical Piping:
 - 1. Sleeve Length: 2 inch (50 mm) above finished floor.
 - 2. Provide sealant for watertight joint.
- F Sleeves for pipe passing through interior walls, partitions, and floors shall be sheet metal unless steel or brass sleeves are specified below.
- G Pipe Passing Through Above Grade Exterior Walls:
 - 1. Less than NPS 6: Steel pipe sleeves.
 - 2. NPS 6 and above: Cast-iron pipe sleeves.
 - 3. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
- H Pipe 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.
- I Pipes passing through above grade floor slabs and masonry walls shall have the space between the pipe or insulation and the sleeve packed with non-asbestos wicking or other suitable, approved, non-combustible material.
- J Pipe Passing Through Concrete Beam Flanges:
 - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 - 2. Connect sleeve with floor plate except in mechanical rooms.
 - 3. Flush with the side of the beam and large enough to accommodate bare pipe only.
- K Clearances:
 - 1. Provide allowance for insulated piping.
 - 2. Wall, Floor, Partitions, and Beam Flanges: minimum 1 inch (25 mm) greater than external pipe diameter.
 - 3. For installation of pipe-sleeve seals: 1 inch (25 mm) greater than external pipe diameter.
 - 4. All Rated Openings and walls of Mechanical Equipment Rooms: Caulked tight with fire stopping material complying with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.

2.2 PIPE-SLEEVE SEALS

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- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Link-Seal.
 - 2. Metraflex Co.
 - 3. Fernco.

- B 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. Carbon steel pressure end plates. Include two for each sealing element.
 - 5. 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.

- C Pipe Sleeve Material:
 - 1. Bearing Walls: Steel, cast iron, or terra-cotta pipe.
 - 2. Masonry Structures: Sheet metal or fiber.

PART 3 EXECUTION

3.1 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.

3.2 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 Structural Considerations: Do not penetrate building structural members unless indicated.

- E Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.

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1. Underground Piping: Caulk pipe sleeve watertight. Provide mechanical sleeve-seal system.
 2. Aboveground Piping:
 - a. Pack solid using mineral fiber complying with ASTM C592.
 - b. Fill space with an elastomer caulk to a depth of 0.50 inch (15 mm) where penetrations occur between conditioned and unconditioned spaces.
 3. All Rated Openings: Caulk tight with fire stopping material complying with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.
 4. Caulk exterior wall sleeves watertight. Provide mechanical sleeve-seal system.
- F 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.
- G 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.

END OF SECTION 220517

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SECTION 220519
METERS AND GAUGES FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Water meters.
- B Gas meters.
- C Pressure gauges.
- D Thermometers.
- E Pressure-temperature test plugs.

1.2 REFERENCE STANDARDS

- A ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).
- B ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014 (Reapproved 2020).
- C ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014 (Reapproved 2021).
- D AWWA C702 - Cold-Water Meters -- Compound Type; 2019.
- E AWWA M6 - Water Meters -- Selection, Installation, Testing, and Maintenance; 2012, with Addendum (2018).
- F Bluetooth CS - Bluetooth Core Specification; 2016, Addendum 2017.
- G IEEE 802.11 - IEEE Standard for Information Technology--Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks--Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications; 2020, with Amendment (2023).

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- H IEEE 802.15.4 - IEEE Standard for Low-Rate Wireless Networks; 2024.
- I LonMark Interoperability Guide - LonMark Application-Layer Interoperability Guide and LonMark Layer 1-6 Interoperability Guide; Version 3.4; 2005.
- J Modbus (PS) - The Modbus Organization Communications Protocol.; Latest Update.
- K NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- L NSF 61 - Drinking Water System Components - Health Effects; 2024.
- M NSF 372 - Drinking Water System Components - Lead Content; 2024.

1.3 SUBMITTALS

- A Product Data: Provide red-marked product data sheets for each furnished item with associated components and accessories.

PART 2 PRODUCTS

2.1 WATER METERS

- A Compound Water Meters:
 - 1. Utility Connection Size: 4 inch (100 mm, DN) flanged.
 - 2. Maximum Unidirectional Water Flow Capacity: As indicated on drawings.
 - 3. Remote Monitoring: Digital register with AMR encoder output interface.
 - 4. Lead-free bronze alloy case, polymer-based cap, and hermetically sealed register.
 - 5. Pressure and Temperature: Up to 150 psi (10 bar) and 100 degrees F (38 degrees C).
 - 6. AWWA C702, with lead content below 0.25 percent when using non-lead-free materials on wetted surfaces according to NSF 61 and NSF 372.
- B ELECTROMAGNETIC FLOW METERS
 - 1. Manufacturers:
 - a. Badger Meter, Inc
 - b. Foxboro, a brand of Schneider Electric
 - c. Onicon, Inc
 - 2. Insertion Type: Include ball valve and threadolet.
 - 3. Lead free suitable for potable water.
 - 4. Liquid Flow Capacity Range: As indicated on drawings.
 - 5. Construction: Stainless steel or aluminum sensor with integral NEMA EN 10250 Type 4 or 4X stainless steel or aluminum enclosure to hold thermal mass sensor and circuits with numeric display for demand, consumption, and other parameter readings.

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6. Transmitter with digital display to include instantaneous flow rate in GPM, totalized flow rate in gallons (hourly, daily, monthly and annual).
7. Accuracy: 0.02 percent of value applied to manufacturer-specified velocity range.
8. Output: Four-wire, 4 to 20 mA, non-loop powered.
9. BAS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet IP.
10. Service Pressure and Temperature: Up to 400 psi (27.6 bar) and 15 to 250 degrees F (minus 9.4 to 125.6 degrees C) liquid side, 150 degrees F (65.5 degrees C) ambient.

2.2 GAS METERS

A Thermal-Mass Natural Gas Meters:

1. Manufacturers:
 - a. Fox Thermal Instruments, Inc: www.foxthermal.com/#sle.
 - b. Onicon, Inc: www.onicon.com/#sle.
 - c. Sierra Instruments, Inc: www.sierrainstruments.com/#sle.
2. Insertion Type: Include ball valve and threadolet.
3. Flow Capacity Range: As indicated on drawings.
4. Remote Monitoring: Display Module for local and remote indication of flow rate and total. Output signals shall be BACnet/IP..
5. Construction: Stainless steel or aluminum sensor with integral NEMA EN 10250 Type 4 or 4X stainless steel or aluminum enclosure with numeric display for demand, consumption, and other parameters readings.
6. Accuracy: Two percent, NIST over measured flow range, adjustable.
7. Output: Two-wire, 4 to 20 mA, non-loop powered.
8. BAS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet IP.
9. Service Pressure and Temperature: Up to 60 psi and minus 40 to 250 degrees F (minus 40 to 125.6 degrees C) gas side, 150 degrees F (65.5 degrees C) ambient.
10. Provide a flow conditioner if required to meet the manufacturer's minimum upstream straight pipe run requirement.

2.3 PRESSURE GAUGES

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Ashcroft, Inc
2. Dwyer Instruments, Inc
3. Terice, H. O. Co.
4. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
5. Weiss Instruments, Inc.

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 (115 mm) diameter.

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3. Mid-Scale Accuracy: One percent.
4. Scale: Psi.

2.4 STEM TYPE THERMOMETERS

- A Manufacturers:
1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 2. Trerice, H. O. Co.
 3. Watts Water Technologies, Inc
 4. Weiss Instruments, LLC
 5. Winters Instruments
- B General:
1. Product Compliance: ASTM E1.
 2. Lens: Clear glass, except where stated.
 3. Accuracy: One percent, when tested in accordance with ASTM E77, except where stated.
 4. Scale: Black markings depicting single scale in degrees F where expected process value falls half-span of standard temperature range.
- C Thermometers - Stem Type Adjustable Angle:
1. 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.

2.5 PRESSURE-TEMPERATURE TEST PLUGS:

- A Test Plug: 1/4 inch (6 mm) or 1/2 inch (13 mm) brass fitting and cap for receiving 1/8 inch (3 mm) outside diameter pressure or temperature probe with Nordel core for temperatures up to 350 degrees F (176 degrees C).

PART 3 EXECUTION

3.1 INSTALLATION

- A Install metering products in accordance with manufacturer's instructions for intended fluid type and service.
- B Install water meters with inlet and outlet isolation valves in compliance with AWWA M6.
- C Install gas meters in accordance with Utility Service Provider instructions with required appurtenances.

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- D Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.
- E Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch (60 mm) for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- F Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.
- G Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- H Install thermowells with extension on insulated piping.
- I Fill thermowells with heat-transfer medium.
- J Provide instruments with scale ranges selected according to service with largest appropriate scale.
- K Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- L Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- M Locate PT (pressure-temperature) test plugs adjacent to control device sockets.

3.2 SCHEDULES

- A Pressure Gauges, Location and Scale Range:
 - 1. Pumps - suction and discharge, 0 to 100 psi (0 to ____ kPa).
- B Stem Type Thermometers, Location and Scale Range:
 - 1. Domestic hot water supply and recirculation, 0 to 200 degrees F (0 to ____ degrees C).

END OF SECTION 220519

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SECTION 220523
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Ball valves.
- B Butterfly valves.
- C Check valves.
- D Gate valves.
- E Globe valves.
- F Chainwheels.
- G Balancing Valves
- H Pressure Reducing Valves
- I Pressure Relief Valves
- J Pressure-Temperature Valves
- K Strainers

1.2 RELATED REQUIREMENTS

- A Division 07 - Firestopping.
- B Division 08 - Access Doors and Panels.
- C Section 220548 - NOT OEC EDITED - Vibration and Seismic Controls for Plumbing Piping and Equipment.

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- D Section 220553 - Identification for Plumbing Piping and Equipment.
- E Section 220719 - Plumbing Piping and Equipment Insulation.
- F Section 221005 - Plumbing Piping.
- G Section 221500 - NOT OEC EDITED - General-Service Compressed-Air Systems.

1.3 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.
- H TFE: Tetrafluoroethylene.
- I WOG: Water, oil, and gas.

1.4 REFERENCE STANDARDS

- A ANSI Z21.22 - American National Standard for Relief Valves for Hot Water Supply Systems; 2015 (Reaffirmed 2020).
- B ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).
- C ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2020.
- D ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard; 2020.

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- E ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves; 2022, with Errata (2023).
- F ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- G ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- H ASME B16.34 - Valves — Flanged, Threaded, and Welding End; 2020.
- I ASME B31.9 - Building Services Piping; 2020.
- J ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers; 2023.
- K 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.
- L ASSE 1003 - Water Pressure Reducing Valves for Potable Water Distribution Systems; 2023.
- M ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2023).
- N ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2022).
- O ASTM A536 - Standard Specification for Ductile Iron Castings; 1984, with Editorial Revision (2019).
- P ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings; 2017.
- Q AWWA C550 - Protective Interior Coatings for Valves and Hydrants; 2024.
- R AWWA C606 - Grooved and Shouldered Joints; 2022.
- S MSS SP-45 - Drain and Bypass Connections; 2020.
- T MSS SP-67 - Butterfly Valves; 2022.
- U MSS SP-70 - Gray Iron Gate Valves, Flanged and Threaded Ends; 2011.

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- V MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends; 2018.
- W MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves; 2019.
- X MSS SP-85 - Gray Iron Globe and Angle Valves, Flanged and Threaded Ends; 2011.
- Y MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .
- Z MSS SP-125 - Check Valves: Gray Iron and Ductile Iron, In-Line, Spring-Loaded, Center-Guided; 2018.
- AA NSF 61 - Drinking Water System Components - Health Effects; 2024.
- BB NSF 372 - Drinking Water System Components - Lead Content; 2024.

1.5 SUBMITTALS

- A See Division 01 - 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.
- E Valves and strainers of the same type shall be of the same manufacturer. Before purchasing valve, the Contractor shall submit for approval the name of the manufacturer, the figure number which he proposes to furnish, and engineering data on each figure number. For manufacturers, see schedules herein.
- F Maintenance Materials:
 - 1. Furnish two packing kits for each size valve.

1.6 QUALITY ASSURANCE

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

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2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.

B Welding Materials and Procedures: Comply with ASME BPVC-IX.

1.7 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.
3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

1.8 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

2.1 GENERAL REQUIREMENTS

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Apollo Valves
2. Crane Fluid Systems; Crane Co.
3. Hammond Valve
4. Jomar Valve

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5. Metraflex Company (The)
 6. Milwaukee Valve Company
 7. Mueller Streamline Co.; a company of Mueller Industries
 8. NIBCO
 9. Stockham; a Crane Co. brand
 10. Victaulic
 11. Viega LLC
 12. WATTS; A Watts Water Technologies Company
- B Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- C Valve Sizes: Match upstream piping unless otherwise indicated.
- D Valve Actuator Types:
1. Gear Actuator: Quarter-turn valves 8 inch (203 mm) and larger.
 2. Handwheel: Valves other than quarter-turn types.
 3. Hand Lever: Quarter-turn valves smaller than 6 inch (153 mm) except plug valves.
 4. Wrench: Plug valves with square heads.
 5. 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.
- E Insulated Piping Valves: With 2 inch (50 mm, DN) 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.
 4. 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 (15 mm, DN) through 24 inch (600 mm, DN): ASME B16.5.
 4. Cast Copper Solder Joint Connections: ASME B16.18.
 5. Wrought-copper solder-joint Connections: ASME B16.22.
 6. Grooved End Connections: AWWA C606.
- G General ASME Compliance:
1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
 2. Cast Copper Solder-joint Connections: ASME B16.18.
 3. Wrought-copper solder-joint Connections: ASME B16.22.
 4. Building Services Piping Valves: ASME B31.9.

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- H 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.
- I Valve Bypass and Drain Connections: MSS SP-45.
- J Source Limitations: Obtain each valve type from a single manufacturer.

2.2 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 Bronze, Brass, or Stainless Steel Trim:
 - 1. Comply with MSS SP-110.
 - 2. CWP Rating: 600 psi (4140 kPa).
 - 3. Body: Forged bronze.
 - 4. Ends Connections: Pipe thread or solder.
 - 5. Seats: PTFE.
 - 6. Stem: Bronze or Stainless Steel, blowout proof.
 - 7. Ball: Chrome plated brass.
 - 8. O-Ring Seal: EPDM or NBR.
- C Three Piece, Full Port with Bronze, Brass, or Stainless Steel Trim:
 - 1. Comply with MSS SP-110.
 - 2. CWP Rating: 600 psi (4140 kPa).
 - 3. Body: Bronze.
 - 4. End Connections: Pipe threaded.
 - 5. Seats: PTFE or TFE.
 - 6. Stem: Bronze or Stainless Steel.
 - 7. Ball: Stainless steel or Chrome plated brass.

2.3 CARBON STEEL, BALL VALVES

- A Two Piece, Full Port, Class 150, Flanged or threaded with Stainless Steel Trim:
 - 1. Comply with MSS SP-72 and MSS SP-110
 - 2. CWP Rating: 285 psi (1964 kPa)
 - 3. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
 - 4. Seats: PTFE
 - 5. Stem: Stainless steel, blowout proof.
 - 6. Ball: Stainless steel, vented.

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7. Pressure and Temperature Rating: ASME B16.34.

2.4 STAINLESS STEEL, BALL VALVES

A Two Piece, Full Port with Stainless Steel Trim:

1. Comply with MSS SP-110.
2. CWP Rating: 1,000 psi (6895 kPa).
3. Body Material: Stainless steel.
4. Seats: PTFE.
5. Stem: Stainless steel, blowout proof.
6. Ball: Stainless steel, vented.
7. End Connections: Threaded or socket weld.
8. O-Ring Seal: EPDM or NBR

B Three Piece, Full Port with Stainless Steel Trim:

1. Comply with MSS SP-110.
2. CWP Rating: 1,000 psi (6895 kPa).
3. Seats: PTFE.
4. Stem: Stainless steel, blowout proof.
5. Ball: Stainless steel, vented.
6. Bolts: Stainless steel.
7. End Connections: Threaded or socket weld.
8. Comply with ASME B16.34 for pressure-temperature range.
9. Extended Working Temperature: Minus 4 to 392 degrees F (Minus 20 to 200 degrees C).

2.5 IRON, BUTTERFLY VALVES

A Lug Style; Bi-directional dead-end service without use of downstream flange:

1. Comply with MSS SP-67, Type I.
2. Lug Style, Service Pressure Ratings:
 - a. 250 psi (1725 kPa) for sizes 2 to 12 inch (50 to 300 mm, DN).
3. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
4. Stem: One or two-piece stainless steel.
5. Seat: EPDM or NBR.
6. Disc: Aluminum-bronze.
7. Finish: Epoxy coated.
8. Operator: Gear operator with handwheel over direct-mount actuator base.
 - a. Provide with Lockable handle for butterfly valves smaller than 8 inch (203 mm).
 - b. Provide with Gear operator with handwheel gear operators with handwheel for butterfly valves 8 inch (203 mm) and larger, and chain wheel operators when mounted over 8 feet (244 cm) above floor

2.6 BRONZE, SWING CHECK VALVES

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- 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 or 4.
 2. Design: Y-pattern, horizontal or vertical flow.
 3. CWP Rating: 200 psi (1380 kPa).
 4. Body: Bronze, ASTM B62.
 5. End Connections: Threaded or soldered.
 6. Disc: Bronze or PTFE ____.
- C Class 150:
1. Pressure and Temperature Rating: MSS SP-80, Type 3 or 4.
 2. Design: Y-pattern, horizontal or vertical flow.
 3. CWP Rating: 300 psi (2068 kPa).
 4. Body: Bronze, ASTM B62.
 5. End Connections: Threaded or soldered.
 6. Disc: Bronze or PTFE. Bronze or PTFE

2.7 IRON, HORIZONTAL SWING CHECK VALVES

- A Class 125:
1. Pressure and Temperature Rating: MSS SP-71, Type I.
 2. Design: T-body style for clear or full waterways.
 3. CWP Rating: 200 psi (1380 kPa).
 4. Body: ASTM A126, gray cast iron with bolted bonnet.
 5. End Connections: Flanged.
 6. Trim: Bronze.
 7. Seat Ring and Disc Holder: Bronze.
 8. Disc: Bronze or Cast Iron.
 9. Gasket: Asbestos free.
- B Class 250:
1. Comply with MSS SP-71, Type I.
 2. CWP Rating: 500 psi (3450 kPa).
 3. Design: T-body style for clear or full waterway.
 4. Body: ASTM A126, gray iron with bolted bonnet.
 5. End Connections: Flanged.
 6. Trim: Bronze and Cast Iron.
 7. Metal Seat.
 8. Gasket: Asbestos free.

2.8 IRON, SWING CHECK VALVES WITH CLOSURE CONTROL

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- A Class 125 with Lever and Spring-Closure or Weight-Closure ____ Control.
1. Comply with MSS SP-71, Type I.
 2. Description:
 - a. CWP Rating: 200 psi (1380 kPa).
 - 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 spring or weight.

2.9 CARBON STEEL, SWING CHECK VALVES

2.10 IRON, GROOVED-END SWING CHECK VALVES

- A Class 300:
1. CWP Rating: 300 psi (2070 kPa).
 2. Body: ASTM A536, Grade 65-45-12 ductile iron.
 3. Seal: NBR.
 4. Disc: Spring operated, ductile iron or stainless steel.
 5. Coating: Black, non-lead paint.

2.11 IRON, CENTER-GUIDED CHECK VALVES

- A Class 125, Compact-Wafer:
1. Comply with MSS SP-125.
 2. CWP Rating: 200 psi (1380 kPa).
 3. Body: ASTM A126 gray iron.
 4. Metal Seat: Bronze.
- B Class 125, Globe:
1. Comply with MSS SP-125.
 2. CWP Rating: 200 psi (1380 kPa).
 3. Body: ASTM A126 gray iron.
 4. Style: Spring loaded.
 5. End Connections: Flanged.
 6. Metal Seat: Bronze.
- C Class 150, Compact-Wafer:
1. Comply with MSS SP-125.
 2. CWP Rating: 300 psi (2070 kPa).
 3. Body: ASTM A395/A395M or ASTM A536, ductile iron.
 4. Metal Seat: Bronze.

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- D Class 150, Globe:
1. Comply with MSS SP-125.
 2. CWP Rating: 300 psi (2070 kPa).
 3. Body: ASTM A395/A395M or ASTM A536, ductile iron.
 4. Style: Spring loaded.
 5. End Connections: Flanged.
 6. Metal Seat: Bronze.

2.12 BRONZE, GATE VALVES

- A General:
1. Fabricate from dezincification resistant material.
 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B Rising Stem or OS&Y:
1. Pressure-Temperature Range: MSS SP-80, Type I or 2.
 2. Class 125:
 - a. CWP Rating: 200 psi (1380 kPa).
 3. Class 150: CWP Rating; 300 psi (2070 kPa).
 4. Body: ASTM B62, bronze with integral seat and screw-in bonnet.
 5. End Connections: Threaded or solder.
 6. Stem: Bronze.
 7. Disc: Solid wedge; bronze.
 8. Packing: Asbestos free.
 9. Handwheel Operator: Malleable iron, bronze, or aluminum.
- C Non-Rising Stem or NRS
1. Pressure-Temperature Range: MSS SP-80, Type I or II.
 2. Class 125:
 - a. CWP Rating: 200 psi (1380 kPa).
 3. Class 150: CWP Rating; 300 psi (2070 kPa).
 4. Body: ASTM B62, bronze with integral seat and screw-in bonnet.
 5. Ends Connections: Threaded or solder.
 6. Stem: Bronze.
 7. Disc: Solid wedge; bronze.
 8. Packing: Asbestos free.
 9. Handwheel Operator: Malleable iron, bronze, or aluminum.

2.13 IRON, GATE VALVES

- A Bolted Bonnet: OS&Y; Rising Stem:
1. Pressure and Temperature Rating: MSS SP-70, Type I.
 2. Class 125: CWP Rating; 200 psi (1380 kPa).
 3. Class 250: CWP Rating; 500 psi (3450 kPa).

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4. Body: ASTM A126, gray iron with bolted bonnet.
5. End Connections: Flanged.
6. Trim: Bronze.
7. Disc: Solid wedge.
8. Packing and Gasket: Asbestos free.
9. Provide chainwheel operators for gate valves 6 inch (152 mm) and larger mounted over 8 feet (244 cm) above floor

2.14 BRONZE, GLOBE VALVES

- A General:
1. Fabricate from dezincification resistant material.
 2. Copper alloys containing more than 15 percent zinc are not permitted.

2.15 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 butterfly and gate valve stems.
 3. Sprocket Rim with Chain Guides: Ductile or cast iron. Include zinc coating.
 4. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.
- B Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Babbitt Steam Specialty Co
 2. Roto Hammer Industries; Rotork
 3. Trumbull Industries
 4. Milwaukee Valve

2.16 BALANCING VALVES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Acorn Controls; a Division of Morris Group International
 2. Anvil International
 3. Apollo Valves; a part of Aalberts Integrated Piping Systems
 4. Bell & Gossett
 5. Caleffi North America
 6. Crane Fluid Systems; Crane Co.
 7. Griswold Controls
 8. Hammond Valve
 9. IMI
 10. Jenkins Valves; a Crane Co. brand
 11. Milwaukee Valve Company

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12. Nexus Valve, Inc.; Aalberts Hydronic Flow Control
 13. NIBCO INC.
 14. Red-White Valve Corp.
 15. Stockham; a Crane Co. brand
 16. Taco, Inc
 17. ThermOmegaTech
 18. WATTS; A Watts Water Technologies Company
- B Construction: Class 125, brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
- C Manual Operated Y-Pattern Globe, Size 1/2 to 2 inch (15 to 50 mm, DN):
1. Class 150, brass or bronze body, multi-turn handwheel, memory stop, variable orifice, soldered connections, dual PT (hot and cold pressure-temperature) test ports for 300 psi (2,068 kPa) 400 psi (2760 kPa), minus 4 to 250 deg F (minus 20 to 121.1 deg C) WOG service.
 2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
 3. Ball: Chrome-plated brass or stainless steel.
 4. Seats and Seals: Replaceable.
 5. Port: Standard or full port.
 6. Handle: Vinyl-covered steel with memory-setting device.
 7. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
- D Automatic Flow Limiting Cartridge:
1. Class 150, brass, bronze, or Stainless steel body, stainless steel cartridge, threaded connections with built-in union, dual PT (hot and cold pressure-temperature) test ports for 400 psi (2,758 kPa), 0.5 gpm (1.9 Lpm) WOG service.
 2. Flow Cartridge: Stainless steel or antiscaling polymer.
- E Calibration: Control flow within five percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi (24 kPa).

2.17 PRESSURE REDUCING VALVES

- A Manufacturers:
1. Amtrol Inc
 2. Apollo Valves
 3. Cash Acme, a brand of Reliance Worldwide Corporation
 4. Cla-Val Company
 5. Flomatic Valves
 6. Watts Regulator Company
 7. Zurn Industries, LLC
- B 2 inch (50 mm, DN) and Smaller:

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1. ASSE 1003, bronze body, stainless steel, and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded single union ends.
 2. Pressure Reducing Pilot-Operator:
 - a. Operating Range: 5 to 50 psi (0.35 to 35 Bar).
 - b. Connected into brass or bronze pilot piping and fittings.
 - c. Fixed flow restrictor, pressure gauges, and isolation valves.
- C 2 inch (50 mm, DN) and Larger:
1. ASSE 1003, cast iron body with interior lining complying with AWWA C550, bronze fitted, elastomeric diaphragm and seat disc, flanged.
 2. Pressure Reducing Pilot-Operator:
 - a. Operating Range: 5 to 50 psi (0.35 to 35 Bar).
 - b. Connected into brass or bronze pilot piping and fittings.
 - c. Fixed flow restrictor, strainer, pressure gauges, and isolation valves.
- D Pilot Operated:
1. Cast bronze, 1-1/2 to 8 inch, NPS (40 to 200 mm, DN) in size with flanged end connections. Rated for 300 psi (2,070 kPa) inlet pressure with outlet discharge field-set to system inlet pressure.

2.18 PRESSURE RELIEF VALVES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Cla-Val Co
 2. Watts Regulator Company
- B ANSI Z21.22, AGA certified, bronze body, teflon seat, steel stem and springs, automatic, direct pressure actuated.

2.19 PRESSURE-TEMPERATURE VALVES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Cla-Val Co; _____: www.cla-val.com/#sle.
 2. Watts Regulator Company
- B ANSI Z21.22, AGA certified, bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, temperature relief maximum 210 degrees F (98.9 degrees C), capacity ASME BPVC-IV certified and labelled.

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2.20 EMERGENCY SHOWERS/EYEWASH STATIONS 1. VALVES 3" AND SMALLER SHALL BE ALL BRONZE BALL VALVES, APOLLO 77-200 OR APOLLO 77C-A, NIBCO 585-70 FULL PORT, SILICON BALL AND 2-PIECE VALVE BODY DESIGNED FOR 600 PSI WOG. 2. ALL ISOLATION/SHUT-OFF VALVES ON SUPPLIES TO EMERGENCY STATIONS (DELUGE SHOWERS, EYE/FACE WASHERS AND DRENCH HOSES) SHALL BE EITHER LOCKED OPEN OR HAVE THE HANDLES REMOVED AND BE LABELED AS "EMERGENCY SHOWER VALVE". 3. PROVIDE SIX (6) MASTER KEYS FOR VALVES LOCKED OPEN. 4. EACH VALVE SHALL BE LABELED "FOR EMERGENCY SHOWER VALVE". 5. MIXING VALVE FOR EMERGENCY SHOWER SHALL BE SYMMONS LEAD FREE THERMOSTATIC TYPE VALVE. MODEL # 7-400A. TEMPERATURE GAUGE PROVIDED WITH ASSEMBLY. C. SANITARY/DRAINAGE VALVES 1. GATE VALVES ON SEWAGE AND DRAINAGE EJECTOR DISCHARGE PIPING SHALL BE NIBCO F-617-0, IRON BODY, BRONZE MOUNTED, SOLID WEDGE, OUTSIDE SCREW AND YOKE, RISING SPINDLE, FLANGED ENDS, 150 PSI. 2. CHECK VALVES ON SEWAGE AND DRAINAGE EJECTOR DISCHARGE PIPING SHALL BE NIBCO F-918L+W IRON BODY, FLANGED ENDS, BRONZE DISC WITH LEVER AND WEIGHT. 3. GATE VALVES FOR SPECIAL WASTE EJECTOR DISCHARGE SHALL BE ASAHI/AMERICA, POLYPROPYLENE, FLANGED ENDS WITH EPDM SEALS, BUBBLE TIGHT, QUICK OPENING VALVE, NON RISING STEM, 100 PSI. 4. CHECK VALVES FOR SPECIAL WASTE EJECTOR DISCHARGE SHALL BE ASAHI/AMERICA, POLYPROPYLENE, FLANGED ENDS, WITH EPDM SEALS AND SEATS, TOP ENTRY, VERTICAL OR HORIZONTAL ORIENTATION. 5. BACKWATER VALVES J.R. SMITH #7012 CAST IRON, BRONZE MOUNTED, HUB END, EXTERIOR SHALL BE WATERPROOFED, BOLTED AND EXTENDED COVER TO SUIT FINISH FLOOR OR GRADE. D. NATURAL GAS VALVES 1. VALVES 3" AND SMALLER SHALL BE APOLLO SERIES 80-100, NIBCO T-585/580-70-UL, THREADED BRONZE BALL VALVE, 600 PSI WOG. 2. VALVES 4" AND LARGER SHALL BE ROCKWELL FIGURE 143, SEMI-STEEL, LUBRICATED PLUG VALVE, FLANGED ENDS, WRENCH OPERATED, 200 PSI WOG.

2.21 3. ALL NATURAL GAS VALVES SHALL BE APPROVED BY THE STATE AND LOCAL CODES.

2.22 STRAINERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Armstrong International, Inc
 - 2. Green Country Filter Manufacturing
 - 3. WEAMCO
- B Size 1/2 inch (15 mm, DN) to 3 inch (80 mm, DN):
 - 1. Class 150, threaded forged bronze Y-pattern body, stainless steel perforated mesh screen with cap, and rated for 150 psi (1,034 kPa), 250 deg F (121.1 deg C) WOG service.
- C Size 2 inch (50 mm, DN) and Smaller:
 - 1. Threaded brass body for 175 psi (1200 kPa) CWP, Y pattern with 1/32 inch (0.8 mm) stainless steel perforated screen.

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2. Class 150, threaded bronze body 300 psi (2070 kPa) CWP, Y pattern with 1/32 inch (0.8 mm) stainless steel perforated screen.
- D Size 1-1/2 inch (40 mm, DN) to 4 inch (100 mm, DN):
 1. Class 125, flanged iron body, Y pattern with 1/16 inch (1.6 mm) stainless steel perforated screen.
- E Size 5 inch (125 mm, DN) and Larger:
 1. Class 125, flanged iron body, basket pattern with 1/8 inch (3.2 mm) stainless steel perforated screen.

PART 3 EXECUTION

3.1 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 be determined to be defective, replace with new valve.
- E Examine press fittings to verify they have been properly pressed.

3.2 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 Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D Install valves in position that does not project into aisles or block access to other equipment.

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- E Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.
- F Where valve support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- G 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 center-guided into horizontal or vertical position, between flanges.
- H Provide chainwheels on operators for 6 inch (150 mm) and larger gate valves and 8 inch (200 mm) 8in and larger for butterfly valves where located 96 inches (2.4 m) or more above finished floor, terminating 60 inches (1.5 m) above finished floor.
- I Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's written recommended maximum.

3.3 ADJUSTING

- A Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 APPLICATIONS

- A Refer to general requirements section of this specification for additional valve information and requirements.
- B See drawings for additional valve locations.
- C Listed pipe sizes shown using nominal pipe sizes (NPS) and nominal diameter (DN).
- D Provide the following valves for the applications if not indicated on drawings:
 - 1. Shutoff: Ball, butterfly, gate.
 - 2. Throttling: Provide ball or butterfly.
 - 3. Swing Check (Pump Outlet):
 - a. 2 inch (50 mm, DN) and Smaller: Bronze swing check valves with bronze disc.
 - b. 2-1/2 inch (65 mm, DN) and Larger for Domestic Water: Iron swing check valves with closure control, metal seat check valves.
 - c. 2-1/2 inch (65 mm, DN) and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

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- E 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.
- F Required Valve End Connections for Wafer Types: Flanged connections.
- G Required Valve End Connections for Non-Wafer Types:
1. Steel Pipe:
 - a. 2 inch (50 mm, DN) and Smaller: Threaded ends.
 - b. 2-1/2 inch (65 mm, DN) and Larger: Flanged ends.
 - c. Grooved-End Steel Piping: Grooved.
 2. Copper Tube:
 - a. 2 inch (50 mm, DN) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 - b. 2-1/2 inch (65 mm, DN) and Larger: Flanged ends.
 - c. Grooved-End Copper Tubing: Grooved.
- H Low Pressure, Compressed Air Valves 150 psi (1035 kPa) or Less:
1. 2 inch (50 mm, DN) and Smaller:
 - a. Bronze: Provide with solder-joint or threaded ends.
 - b. Ball: Two piece, full port, bronze with brass, bronze, or stainless steel trim.
- I High Pressure, Compressed Air Valves 150 psi (1035 kPa) to 200 psi (1380 kPa):
1. 2 inch (50 mm, DN) and Smaller:
 - a. Bronze: Provide with solder-joint or threaded ends.
 - b. Ball: Two piece, full port, bronze with brass, bronze, or stainless steel trim.
- J Domestic, Hot and Cold Water Valves:
1. 2 inch (50 mm, DN) and Smaller:
 - a. Bronze: Provide with solder-joint or threaded ends.
 - b. Ball: Two piece, full port, bronze with stainless-steel trim.
 - c. Bronze Swing Check: Class 125, bronze disc.
 - d. Bronze Gate: Class 125, NRS.
 - e. Bronze Gate for Water Service Entry: Class 125, OS&Y
 2. 2-1/2 inch (65 mm, DN) and Larger:
 - a. Iron, 2-1/2 inch (65 mm, DN) and larger 4 inch (100 mm, DN): Provide with flanged ends.
 - b. Iron Butterfly: 200 CWP, EPDM seat, ductile-iron disc.
 - c. Iron Swing Check: Class 125, metal seats.
 - d. Iron Swing Check with Closure Control: Class 125, lever and spring.
 - e. Iron Gate: Class 125, NRS.
 - f. Bronze Gate for Water Service Entry: Class 125, OS&Y
- K Sanitary Waste and Storm Drainage Water Valves:
1. 2 inch (50 mm, DN) and Smaller:

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- a. Bronze: Provide with solder-joint or threaded.
- b. Ball: Two piece, full port, bronze with stainless-steel trim.
- c. Bronze Swing Check: Class 125, bronze disc.
- 2. 2-1/2 inch (65 mm, DN) and Larger:
 - a. Iron, 2-1/2 inch (65 mm, DN) and larger: Provide with flanged ends.
 - b. Iron Swing Check: Class 125, metal seats.
 - c. Iron Gate: Class 125, NRS.

END OF SECTION 220523

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SECTION 220529
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT - PENDING APPROVAL

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Prefabricated trapeze-framed systems.
- B Strut systems for pipe or equipment support.
- C Beam clamps.
- D Pipe hangers.
- E Pipe rollers and roller supports.
- F Pipe supports, guides, shields, and saddles.
- G Anchors and fasteners.

1.2 RELATED REQUIREMENTS

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

1.3 REFERENCE STANDARDS

- A ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- B ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.
- C ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping; 2023.

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- D ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.
- E ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2022).
- F ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates; 2018.
- G ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2022).
- H ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- I 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; 2023.
- J ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- K ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2023.
- L FM (AG) - FM Approval Guide; Current Edition.
- M MFMA-4 - Metal Framing Standards Publication; 2004.
- N MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2018, with Amendment (2019).
- O UL (DIR) - Online Certifications Directory; Current Edition.
- P UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordination:

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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/Engineer 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 Division 03.

1.5 SUBMITTALS

- A See Division 01 and Section 220500 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.
1. Fiberglass Strut Channel Framing Systems: Include requirements for strength derating according to ambient temperature.
- C Shop Drawings: Include details for fabricated hangers and supports.
1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.
- D Derating Calculations for Fiberglass Strut Channel Framing Systems: Indicate load ratings adjusted for applicable service conditions.
- E Evaluation Reports: For products specified as requiring evaluation and recognition by ICC Evaluation Service, LLC (ICC-ES), provide current ICC-ES evaluation reports upon request.
- F Installer's Qualifications: Include evidence of compliance with specified requirements.
- G 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.

1.6 QUALITY ASSURANCE

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- A Comply with applicable building code.
- B Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C Installer Qualifications for Field-Welding: As specified in Section Division 05.
- D Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A Structural Performance: Hangers and supports for plumbing piping and equipment are to withstand the effects of gravity loads and stresses within limits and under conditions indicated in accordance with ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- B Provide required hardware to hang or support piping, equipment, or fixtures with related accessories as necessary to complete installation of plumbing work.
- C Provide hardware products listed, classified, and labeled as suitable for intended purpose.
- D 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. Include consideration for vibration, equipment operation, and shock loads where applicable.
- E Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
- F Fire Resistance: Provide hardware rated for 60 minutes resistance unless specifically indicated by the authority having jurisdiction.

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- G Materials for Metal Fabricated Supports: Comply with Section Division 05.
 - 1. Galvanized Steel: Hot-dip galvanized in accordance with ASTM A123/A123M or ASTM A153/A153M unless stated otherwise.
- H Corrosion Resistance: Use corrosion-resistant metal-based materials fully compatible with exposed piping materials and suitable for the environment where installed.
 - 1. Indoor Dry Locations: Use material indicated in this specification.
 - 2. Outdoor, Damp, or Wet-Indoor, Coastal Locations, Coastal: Use Type 304 stainless steel.
 - 3. Corrosive Chemical Environment or Exterior Supports for Coastal Areas: Use Type 316 stainless steel.
- I 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. Copper coated, Plated or colored hangers and supports and not acceptable.

2.2 MANUFACTURERS

- A Furnish all hangers, supports, hardware, fittings, and accessories from single manufacturer.
- B Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Anvil International, LLC.
 - 2. Cooper B-line; brand of Eaton, Electrical Sector
 - 3. Gripple, Inc.
 - 4. Unistrut, a brand of Atkore International, Inc.

2.3 SECONDARY PIPE POSITIONING AND SUPPORTS:

- A Support and positioning of piping shall be by means of engineered methods that comply with IAPMO PS 42-96. These shall be hubbard enterprises/holdrite support systems or owner-approved equivalent.
- B For plenum applications use pipe supports that meet ASTM E-84 25/50 standards, such as the hubbard enterprises/holdrite flame fighter tm or owner-approved equivalent.
- C For vertical mid-span supports of piping 4" and under, use hubbard enterprises/holdrite stout brackets with hubbard enterprises/holdrite stout clamps or two-hole pipe clamps (MSS type 26).
- D Provide rubber coated, plastic, or epoxy coated hangers and supports for copper piping. Copper coated, plated or colored hangers and supports are not acceptable.

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- E Makeshift, field devised methods of plumbing pipe positioning and supports, such as with the use of scrap framing materials, are not allowed.

2.4 PREFABRICATED TRAPEZE-FRAMED SYSTEMS

- A Prefabricated Trapeze-Framed Metal Strut Systems:
 - 1. MFMA-4 compliant, pre-fabricated, MSS SP-58 Type 59 continuous-slot metal strut channel with associated tracks, fittings, and related accessories.
 - 2. Strut Channel or Bracket Material:
 - a. Indoor Dry Locations: Use galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use Stainless Steel.
 - 3. Accessories: Provide bracket covers, cable basket clips, cable tray clips, clamps, conduit clamps, fire-retarding brackets, j-hooks, protectors, and vibration dampeners.

2.5 STRUT SYSTEMS FOR PIPE OR EQUIPMENT SUPPORT

- A Strut Channels:
 - 1. ASTM A653/A653M galvanized steel bracket with clamps for surface mounting of piping or plumbing equipment support.
 - 2. Channel or Bracket Kits: Include rods, brackets, end-fixed fittings, covers, clips, and other related hardware required to complete sectional trapeze section for piping or other support.
- B Hanger Rods:
 - 1. Threaded carbon steel unless otherwise indicated.
 - 2. Minimum Size in accordance with MSS SP-58
 - a. Piping 1/2 to 4 inch: 1/4 inch (6 mm, DN) diameter.
 - b. Piping 5 to 8 inch: 3/8 inch (10 mm, DN) diameter.
 - c. Piping 10 to 12 inch: 5/8 inch diameter.
- C Channel Nuts:
 - 1. Provide carbon steel channel nut with galvanized steel or stainless steel finish.

2.6 BEAM CLAMPS

- A FM (AG) and UL (DIR) Approved Beam Clamp: MSS SP-58
- B Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- C 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.

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2.7 PIPE HANGERS

- A Band Hangers, Adjustable:
1. MSS SP-58 type 7 or 9, ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized
 3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
- B J-Hangers, Adjustable:
1. MSS SP-58 type 5, ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
 4. Felt-Lined: Provide for uninsulated pipe to reduce noise and prevent static issues.
- C Swivel Ring Hangers, Adjustable:
1. MSS SP-58 type 10, epoxy-painted, zinc-colored.
 2. 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.
 3. FM (AG) and UL (DIR) listed for specific pipe size runs and loads.
 4. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 5. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
 6. Felt-Lined: Provide for uninsulated pipe to reduce noise and prevent static issues.
- D Clevis Hangers, Adjustable:
1. Copper Tube: MSS SP-58 type 1, epoxy-plated copper.
 2. Felt-Lined: MSS SP-58 type 1, zinc-plated, silicone-free carbon steel.
 3. Light-Duty: MSS SP-58 type 1, zinc-colored, epoxy plated.
 4. Standard-Duty: MSS SP-58 type 1, zinc-colored, epoxy plated.
 5. UL listed
 6. FM listed
 7. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 8. Nonmetallic Coatings: Plastic coated or epoxy powder coated

2.8 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. 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.
 4. UL listed

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- B Offset Pipe Clamps: Double-leg design two-piece pipe clamp.
- C Strut Clamps:
 - 1. Pipe Clamp: Two-piece rigid, universal, or outer diameter type, carbon steel with epoxy copper or zinc finish.
 - 2. Cushioned Pipe or Tubing Strut Clamp: Provide strut clamp with thermoplastic elastomer cushion having dielectric strength of 670 V/mil (26,398,000 V/m).
 - 3. Service Temperature Range: Minus 65 to 275 degrees F (Minus 53.8 to 135 degrees C).
- D Insulation Coupling:
 - 1. Two bolt-type clamps designed for installation under insulation.
 - 2. Material: Carbon steel with epoxy copper, epoxy plated, galvanized steel, stainless steel, or zinc finish.

2.9 PIPE ROLLERS AND ROLLER SUPPORTS

- A MSS SP-58 type 43 based on required load, nonconductive and corrosion resistant.
- B Steel Yoke Type: MSS SP-58 type 44, vertically adjustable, nonconductive, and corrosion resistant.
- C Material: Zinc plated ASTM A36/A36M carbon steel or ASTM A47/A47M malleable iron.

2.10 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. Copper coated, Plated or colored hangers and supports and not acceptable.
- B Stanchions:
 - 1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 - 2. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
 - 3. For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.
- C U-Bolts:
 - 1. MSS SP-58 type 24, carbon steel u-bolt for pipe support or anchoring.
- D Intermediate Anchors and Pipe Alignment Guides:

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1. Manufacturers:
 - a. Advanced Thermal Systems, Inc
 - b. Anvil International, LLC
 - c. ASC Engineered Solutions
 - d. B-Line, a brand of Eaton Corporation
 - e. Flex-Hose Co., Inc
 - f. Flex-Weld; a division of Kelco
 - g. Flexicraft Industries
 - h. Gregory Industries, Inc
 - i. Hyspan Precision Products, Inc
 - j. The Metraflex Company
 - k. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 2. Pipe Sizes 6 inch (150 mm, DN) and Smaller: Minimum clearance of 0.16 inch (4 mm).
 3. Pipe Size 8 inch (200 mm, DN): 0.625 inch (16 mm) U-bolt with double nuts providing minimum clearance of 0.28 inch (7 mm).
 4. Pipe Size 10 inch (250 mm, DN): 0.75 inch (19 mm) U-bolt.
 5. Pipe Sizes 12 to 16 inch (300 to 400 mm, DN): 0.875 inch (24 mm) U-bolt.
 6. Pipe Sizes 18 to 30 inches (450 to 750 mm, DN): 1 inch (25 mm) U-bolt.
 7. Use pipe clamps with oversize pipe sleeve that provides clearance around pipe.
- E Pipe Alignment Guides:
1. Manufacturers:
 - a. Advanced Thermal Systems, Inc
 - b. Anvil International
 - c. ASC Engineered Solutions
 - d. B-Line, a brand of Eaton Corporation
 - e. Flex-Hose Co., Inc
 - f. Flex-Weld; a division of Kelco
 - g. Flexicraft Industries
 - h. Gregory Industries, Inc
 - i. Hyspan Precision Products, Inc
 - j. The Metraflex Company
 - k. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 2. Pipe Sizes 2-1/2 inch (65 mm, DN) and Larger: Roller type. For if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
 3. Pipe Sizes 1/2 to 30 inch (15 mm, DN): 1 inch (25 mm) U-bolt. For support of heavy pipes
- F Pipe Shields for Insulated Piping:
1. Manufacturers:
 - a. Anvil International
 - b. FNW
 - c. Gregory Industries, Inc

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- d. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. MSS SP-58 type 40, ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
 - 3. 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 (321 mm).
 - d. Service Temperature: Minus 40 to 178 degrees F (Minus 40 to 81 degrees C).
 - e. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- G 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 (50 degrees C):
 - a. Overhead Support: MSS SP-58 types 1, 3 through 12 clamps.
 - b. Support From Below: MSS SP-58 types 35 through 38.
 - 3. Operating Temperatures from 122 to 446 degrees F (50 to 230 degrees C):
 - a. Overhead Support: MSS SP-58 type 1 or 3 through 12 clamps with appropriate saddle of MSS SP-58 type 40 for insulated pipe.
 - b. Roller Chair: MSS SP-58 types 41 or 43 through 46 roller chair support with appropriate saddle of MSS SP-58 type 39 for insulated pipe.
 - c. Sliding Support: MSS SP-58 types 35 through 38.
- H Nonpenetrating Pipe Supports:
- 1. Manufacturers:
 - a. Green Link, Inc
 - b. Source Limitations: Furnish channels/struts and associated fittings, accessories, and hardware produced by a single manufacturer.
- I Pipe Supports, Thermal Insulated:
- 1. Manufacturers:
 - a. Aeroflex USA
 - b. Buckaroos, Inc
 - c. Carpenter & Paterson, Inc
 - d. KB Enterprise
 - e. National Pipe Hanger Corporation
 - f. Pipe Shields Inc.
 - g. Piping Technology & Products, Inc
 - h. Rilco Manufacturing Co., Inc
 - i. Value Engineered Products, Inc
 - 2. General Requirements:
 - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.

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- 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. Provide pipe supports for 1/2 to 30 inch (15 to 750 mm, DN) iron pipes.
 - d. Insulation inserts to consist of rigid phenolic foam insulation surrounded by 360 degree, PVC jacketing.
- 3. 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 (0.0092 ng/Pa s m), when tested in accordance with ASTM E96/E96M.
 - c. Minimum Thickness: 60 mil, 0.06 inch (1.524 mm).
- 4. Products:
 - a. Aeroflex USA
 - b. Buckaroos, Inc
 - c. Carpenter & Paterson, Inc
 - d. KB Enterprise
 - e. National Pipe Hanger Corporation
 - f. Pipe Shields Inc.
 - g. Piping Technology & Products, Inc
 - h. Rilco Manufacturing Co., Inc
 - i. Value Engineered Products, Inc

2.11 ANCHORS AND FASTENERS

- A Manufacturers - Mechanical Anchors:
 - 1. FNW
 - 2. Hilti, Inc
 - 3. ITW Red Head, a division of Illinois Tool Works, Inc
 - 4. Powers Fasteners, Inc
 - 5. Simpson Strong-Tie Company Inc
- B Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
- C Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
- D Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
- E Hollow Masonry: Use toggle bolts.
- F Hollow Stud Walls: Use toggle bolts.

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- G Steel: Use beam ceiling clamps, beam clamps, machine bolts, or welded threaded studs.
- H Beam Ceiling Flanges: ASTM A47/A47M Grade 32510, malleable iron or stainless steel with copper, plain, stainless steel, or zinc finish.
- I Sheet Metal: Use sheet metal screws.
- J Wood: Use wood screws.
- K Plastic and lead anchors are not permitted.
- L Powder-actuated fasteners are not permitted.
- M Hammer-driven anchors and fasteners are not permitted.
- N Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.
- O 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.
- P Concrete Inserts:
 - 1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation
 - b. HoldRite, a brand of Reliance Worldwide Corporation
 - c. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.

PART 3 EXECUTION

3.1 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.

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3.2 INSTALLATION

- A Comply with requirements in assemblies. Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination is to include weight of supported components plus 200 lb (90 kg).
- C Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- D Install lateral bracing with pipe hangers and supports to prevent swaying.
- E Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, 2-1/2 inch (65 mm) and larger and at changes in direction of piping. Coordinate location of concrete inserts before concrete is placed.
- F Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- G Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- H Install products in accordance with manufacturer's instructions.
- I Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- J Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- K Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- L Unless specifically indicated or approved by Architect, do not provide support from roof deck.

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- M Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- N Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.
- O Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.
- P 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 3 inch (80 mm) 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.
- Q Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.
- R Secure fasteners according to manufacturer's recommended torque settings.
- S Remove temporary supports.
- T Insulated Piping:
1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

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2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Thermal hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe 4 inch (100 mm) and larger if pipe is installed on rollers.
 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields are to span an arc of 180 degrees.
 - a. Thermal hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe 4 inch (100 mm) and larger if pipe is installed on rollers.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a. 1/4 inch (8 mm) to 3-1/2 inch (90 mm): 12 inch (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. 4 inch (100 mm): 12 inch (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. 5 inch (125 mm) and 6 inch (150 mm): 18 inch (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. 8 inch (200 mm) to 14 inch (350 mm): 24 inch (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. 16 inch (400 mm) to 24 inch (600 mm): 24 inch (610 mm) long and 0.105 inch (2.67 mm) thick.
 5. Pipes 8 inch (200 mm) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
- U Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 2. Field fabricate in accordance with ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.
- V FRP Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.
- W Strut System Installation: Metal, rod type, Metal, cable type, or FRP ; arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems. Install in accordance with manufacturer's written installation instructions.
- X Thermal Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- Y Fastener System Installation:
1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners in accordance with manufacturer's written instructions.
 2. Install lag screw wood fasteners in accordance with manufacturer's written instructions.
 3. Install fasteners in accordance with manufacturer's written instructions.

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Z Pipe Stand Installation:

1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

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

CC Equipment Support Installation:

1. Fabricate from welded-structural-steel shapes.
2. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
3. Grouting: Place grout under supports for floor-mounted equipment, and make bearing surface smooth.
4. Provide lateral bracing, to prevent swaying.

3.3 ADJUSTING

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

B Trim excess length of continuous-thread hanger and support rods to 1-1/2 inch (13 mm).

3.4 PAINTING

A Touchup:

1. Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - a. Apply paint by brush or spray to provide a minimum dry film thickness of 2 mils (0.05 mm).
2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.5 HANGER AND SUPPORT SCHEDULE

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- A Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F Use stainless steel pipe hangers and stainless steel attachments for hostile environment
 - 1. Hostile Environments include: Pool Equipment Room, Chemical Storage Rooms, Natatoriums, and Coastal Areas
- G Use padded hangers for piping that is subject to scratching.
- H Use thermal hanger shield inserts for insulated piping and tubing.
- I Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes 1/2 inch (15 mm) to 30 inch (750 mm).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 degrees F pipes 4 inch (100 mm) to 24 inch (600 mm), requiring up to 4 inch (100 mm) of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes 3/4 inch (20 mm) to 36 inch (900 mm), requiring clamp flexibility and up to 4 inch (100 mm) of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes 1/2 inch (15 mm) to 24 inch (600 mm) if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes 1/2 inch (15 mm) to 4 inch (100 mm), to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes 3/4 inch (20 mm) to 8 inch (200 mm).
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes 1/2 inch (15 mm) to 8 inch (200 mm).
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes 1/2 inch (15 mm) to 8 inch (200 mm).
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes 1/2 inch (15 mm) to 8 inch (200 mm).

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10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes 3/8 inch (10 mm) to 8 inch (200 mm).
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes 3/8 inch (10 mm) to 3 inch (80 mm).
 12. U-Bolts (MSS Type 24): For support of heavy pipes 1/2 inch (15 mm) to 30 inch (750 mm).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes 4 inch (100 mm) to 36 inch (900 mm), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes 4 inch (100 mm) to 36 inch (900 mm), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes 2-1/2 inch (65 mm) to 36 inch (900 mm) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes 1 inch (25 mm) to 30 inch (750 mm), from two rods if longitudinal movement caused by expansion and contraction occurs.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes 2-1/2 inch (65 mm) to 24 inch (600 mm), from single rod if horizontal movement caused by expansion and contraction occurs.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes 2 inch (50 mm) to 42 inch (1050 mm) if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes 2 inch (50 mm) to 24 inch (600 mm) if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes 2 inch (50 mm) to 30 inch (750 mm) if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.
- J Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers 3/4 inch (20 mm) to 24 inch (600 mm).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers 3/4 inch (20 mm) to 24 inch (600 mm) if longer ends are required for riser clamps.
- K Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inch (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 deg F (49 deg C) to 450 deg F (232 deg C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.

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4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 deg F (49 deg C) to 450 deg F (232 deg C) piping installations.
- L Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal Hanger Shield Inserts: For supporting insulated pipe.

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- N Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inch (32 mm).
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- O Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- P Use mechanical-expansion anchors instead of building attachments where required in concrete construction.
- Q Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.6 FIELD QUALITY CONTROL

- A See Section 014000 - NOT OEC EDITED - 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.

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D Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION 220529

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SECTION 220533
HEAT TRACING FOR PLUMBING PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Self-regulating parallel resistance electric heating cable.
- B Cable outer jacket markings.
- C Connection kits.
- D Accessories.
- E Controls.

1.2 RELATED REQUIREMENTS

- A Section 220719 - Plumbing Piping and Equipment Insulation.
- B Section 221005 - Plumbing Piping.

1.3 REFERENCE STANDARDS

- A IEEE 515.1 - IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications; 2022.
- B ITS (DIR) - Directory of Listed Products; Current Edition.
- C NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D UL (DIR) - Online Certifications Directory; Current Edition.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordinate the work with other trades to provide ground fault protection for electric heat tracing circuits as required by NFPA 70.

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- B Coordinate the work with other trades to provide circuit breaker ratings suitable for installed circuit lengths.

1.5 SUBMITTALS

- A See Section 013000 - Administrative Requirements, for submittal procedures.
- B Product Data: Provide data for electric heat tracing.
- C Shop Drawings: Indicate electric heat tracing layout, electrical terminations, thermostats, controls, and branch circuit connections.
- D Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions of equipment and controls, maintenance and repair data, and parts listings.
- E Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.6 WARRANTY

- A Provide two year manufacturer warranty for cables, connection kits, accessories, and controls.

PART 2 PRODUCTS

2.1 SELF-REGULATING PARALLEL RESISTANCE ELECTRIC HEATING CABLE

- A Manufacturers:
 - 1. Chromalox, Inc
 - 2. Pentair
 - 3. Thermon Manufacturing Company
 - 4. Raychem
- B Provide products listed, classified, and labeled by UL (DIR), ITS (DIR), or testing firm acceptable to authorities having jurisdiction (AHJ).
- C Factory Rating and Testing: Comply with IEEE 515.1.
- D Heating Element:

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1. Provide pair of parallel No.16 tinned or nickel coated stranded copper bus wires embedded in cross linked conductive polymer core with varying heat output in response to temperature along its length.
2. Terminations: Waterproof, factory assembled, non-heating leads with connector at one end and water-tight seal at opposite end.
3. Capable of crossing over itself without overheating.

E Insulated Jacket: Flame retardant polyolefin.

F Cable Cover: Provide tinned copper and polyolefin outer jacket with UV inhibitor.

G Maximum Power-On Operating Temperature: 150 degrees F (65 degrees C).

H Maximum Power-Off Exposure Temperature: 185 degrees F (85 degrees C).

I Electrical Characteristics: As scheduled

2.2 CABLE OUTER JACKET MARKINGS

A Name of manufacturer, trademark, or other recognized symbol of identification.

B Catalog number, reference number, or model.

C Month and year of manufacture, date coding, applicable serial number, or equivalent.

D Agency listing or approval.

2.3 CONNECTION KITS

A Provide power connection, splice/tee, and end seal kits compatible with the heating cable and without requiring cutting of the cable core to expose bus wires.

B Provide with NEMA 4X rating for prevention of corrosion and water ingress.

2.4 ACCESSORIES

A Provide Accessories As Indicated or As Required for Complete Installation, Including but Not Limited To:

1. High temperature, glass filament tape for attachment of heating cable to metal piping.
2. Aluminum self-adhesive tape for attachment of heating cable to plastic piping.
3. Heat-conductive putty.

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4. Cable ties.
5. Silicone end seals and splice kits.
6. Installation clips.
7. Provide with insulation to match existing heat trace domestic water systems, provide with matching PVC jacket.

2.5 CONTROLS

- A Pipe Mounted Thermostats:
1. Remote bulb on capillary, resistance temperature device (RTD) or thermistor for direct sensing of pipe wall temperature.
 2. Control Enclosure: Corrosion resistant and waterproof.
- B Line sensing high-limit temperature control and high-limit alarm.
- C Programmable Controller:
1. Micro-processor based.
 2. On/Off/Auto switch.

2.6 INSULATION

- A 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.

PART 3 EXECUTION

3.1 PREPARATION

- A Clean exposed surfaces prior to installation.
- B Prepare surfaces using approved methods as recommended by manufacturer.

3.2 INSTALLATION

- A Install in accordance with manufacturer's written installation instructions.
- B Comply with installation requirements of IEEE 515.1 and NFPA 70, Article 427.
- C Apply heating cable linearly on pipe with fiberglass tape only after piping has successfully completed any required pressure testing.

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D Comply with applicable local building codes and requirements of authorities having jurisdiction.

E Identification:

1. After thermal insulation installation, apply external pipeline decals to indicate presence of the thermal insulation cladding at intervals not to exceed 20 ft (6 m) including cladding over each valve or other equipment that may require maintenance.

3.3 FIELD QUALITY CONTROL

A Perform start-up by factory technician or factory representative as per Owner's requirements.

B Field Testing and Inspections:

1. Commission system in accordance with installation and operation manual.
2. Inspect for sources of water entry and proper sealing.
3. Inspect weather barrier to confirm that no sharp edges are contacting the trace heating.
4. Insulation Resistance: Greater than 20 megohms at a test voltage of 2500 VDC for polymer insulated trace heaters.
5. Test heating cable integrity with megohmmeter at the following intervals:
 - a. After cable has been installed onto the piping.
 - b. After the installation of thermal insulation onto the piping.
6. Measure voltage and current at each unit.
7. Controls:
 - a. Verify control parameters are set to the application requirements.

END OF SECTION 220533

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SECTION 220553
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Nameplates.
- B Tags.
- C Stencils.
- D Pipe markers.
- E Underground warning tape.
- F Ceiling tacks.

1.2 RELATED REQUIREMENTS

- A Division 09 - Interior Painting: Identification painting.
- B Section 226000 - Gas and Vacuum Systems for Laboratory and Healthcare Facilities: Supply of pipe labels for placement under this section.

1.3 REFERENCE STANDARDS

- A ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.
- B ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2017.

1.4 SUBMITTALS

- A See Division 01 and section 220500 for submittal procedures.
- B Schedules:
 - 1. Submit plumbing component identification schedule listing equipment, piping, and valves.

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C Product Data: Provide manufacturers catalog literature for each product required.

D Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.1 PLUMBING COMPONENT IDENTIFICATION GUIDELINE

A Nameplates:

1. Heat exchangers, water heaters, and other heat transfer products.
2. Control panels, transducers, and other related control equipment products.
3. Pumps, tanks, filters, water treatment devices, and other plumbing equipment products.

B Tags:

1. Manual operated and automated control valves.
2. Instrumentation, relays, gauges, and other related control equipment products.
3. Ceiling tacks placed on lay-in ceiling surface to reference plumbing components.

C Stencil:

1. Ceiling tacks placed on lay-in ceiling surface to reference plumbing components.

D Pipe Markers: All piping.

2.2 NAMEPLATES

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Brimar Industries, Inc
2. Craftmark Pipe Markers
3. Kolbi Pipe Marker Co
4. Seton Identification Products

B Description: Laminated piece with up to three lines of text.

1. Letter Color: White.
2. Letter Height: 1/4 inch (6 mm).
3. Background Color: Black.
4. Nameplate Height: 3/4 inch (19 mm).
5. Nameplate Material:
 - a. Flexible: Vinyl with adhesive backing per ASTM D709.
 - b. Metal: Brass with center-side holes for screw fastening.

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2.3 TAGS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Brimar Industries, Inc
 2. Craftmark Pipe Markers
 3. Kolbi Pipe Marker Co
 4. Seton Identification Products
 5. _____
- 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 (40 mm) in diameter.
- C Metal: Brass, 19 gauge 1-1/2 inch (40 mm) in diameter with smooth edges, blank, smooth edges, and corrosion-resistant ball chain. Up to three lines of text.
- D Valve Tag Chart: Typewritten 12-point letter size list in anodized aluminum frame.

2.4 STENCILS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Brady Corporation
 2. Craftmark Pipe Markers
 3. Insite Solutions, LLC
 4. Kolbi Pipe Marker Co
 5. Seton Identification Products
 6. _____.
- B Pipe: Stencil size required per external insulated or uninsulated pipe diameter.
1. 3/4 to 1-1/4 inch (20 to 30 mm) Range: 1/2 inch (15 mm) text over 8 inch (200 mm) long background.
 2. 1-1/2 to 2 inch (40 to 50 mm) Range: 3/4 inch (20 mm) text over 8 inch (200 mm) long background.
 3. 2-1/2 to 6 inch (65 to 150 mm) Range: 1-1/4 inch (30 mm) text over 12 inch (300 mm) long background.
 4. 8 to 10 inch (200 to 250 mm) Range: 2-1/2 inch (65 mm) text over 24 inch (600 mm) long background.
 5. Over 10 inches (250 mm): 3-1/2 inch (90 mm) text over 32 inch (800 mm) long background.
- C Equipment: Use 2-1/2 inch (65 mm) text using Owner defined scheme.

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D Background Paint: Semi-gloss enamel in compliance with Section 099123.

2.5 PIPE MARKERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Brady Corporation
 2. Brimar Industries, Inc
 3. Craftmark Pipe Markers
 4. Kolbi Pipe Marker Co
 5. Seton Identification Products
 6. _____.
- 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 Flexible Tape Marker: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.
- E Underground Flexible Marker: Bright-colored continuously printed ribbon tape, minimum 6 inches (150 mm) wide by 4 mil, 0.004 inch (0.10 mm) thick, manufactured for direct burial service.
- F Identification Scheme, ASME A13.1:
1. Primary: External Pipe Diameter, Uninsulated or Insulated.
 - a. 3/4 to 1-1/4 inches (19 to 32 mm): Use 8 inch (203 mm) field-length with 1/2 inch (13 mm) text height.
 - b. 1-1/2 to 2 inches (38 to 51 mm): Use 8 inch (203 mm) field-length with 3/4 inch (19 mm) text height.
 - c. 2-1/2 to 6 inches (64 to 152 mm): Use 12 inch (305 mm) field-length with 1-1/4 inch (32 mm) text height.
 - d. 8 to 10 inches (204 to 254 mm): Use 24 inch (610 mm) field-length with 2-1/2 inch (64 mm) text height.
 - e. Over 10 inches (over 254 mm): Use 32 inch (813 mm) field-length with 3-1/2 inch (89 mm) text height.
 2. Tertiary: Other Details.
 - a. Directional flow arrow.
 - b. Line pressure.
 - c. Line temperature.

2.6 UNDERGROUND WARNING TAPE

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- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Brady Corporation
 2. Brimar Industries, Inc
 3. Kolbi Pipe Marker Co
 4. Seton Identification Products
 5. _____.
- B Materials: Use polyethylene tape suitable for direct burial, unless otherwise indicated.
1. Exception: Use foil-backed detectable type tape where required by serving utility or where directed by Owner.
- C Non-detectable Type Tape: 6 inches (152 mm) wide, with minimum thickness of 4 mil, 0.004 inch (0.10 mm).
- D Foil-backed Detectable Type Tape: 3 inches (76 mm) wide, with minimum thickness of 5 mil, 0.005 inch (0.12 mm), unless otherwise required for proper detection.
- E Legend: Type of service, continuously repeated over full length of tape.
- F Color:
1. Tape for Buried Power Lines: Black text on red background.
 2. Tape for Buried Communication, Alarm, and Signal Lines: Black text on orange background.

2.7 CEILING TACKS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Brady Corporation
 2. Brimar Industries, Inc
 3. Craftmark Pipe Markers
 4. Brimar Industries, Inc
 5. Kolbi Pipe Marker Co
 6. Seton Identification Products
- B Description: Steel with 3/4 inch (20 mm) diameter color coded head.
- C Color code as follows:
1. Plumbing Equipment: Yellow.
 2. Plumbing Valves: Green.
 3. Heating/Cooling Valves: Blue.

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PART 3 EXECUTION

3.1 PREPARATION

- A Degrease and clean surfaces to receive identification products.
- B Prepare surfaces for stencil painting, see Division 09.

3.2 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 Division 09 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 (150 to 200 mm) below finished grade, directly above buried pipe.
- G Apply ASME A13.1 Pipe Marking Rules:
 - 1. Place pipe marker adjacent to changes in direction.
 - 2. Place pipe marker near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Place pipe marker adjacent to each valve port and flange end.
 - 4. Place pipe marker near major equipment and other points of origination or termination.
 - 5. Place pipe marker at both sides of floor and wall penetrations.
 - 6. Place pipe marker at access doors, manholes, and similar access points that permit view of concealed pipe.
 - 7. Place pipe marker every 25 feet (7.6 m) interval of straight run.
- H Install ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.
- I Color coding and identification nomenclature used with labels shall be in accordance with ASME A13.1 per the table below.

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1. Low-Pressure Compressed-Air Piping: White letters on an ANSI Z535.1 safety-blue background.
2. High-Pressure Compressed-Air Piping: White letters on an ANSI Z535.1 safety-blue background.
3. Vacuum Piping: White letters on an ANSI Z535.1 safety-blue background.
4. Domestic Cold-Water Piping: White letters on an ANSI Z535.1 safety-green background.
5. Domestic Hot-Water Piping: White letters on an ANSI Z535.1 safety-green background.
6. Domestic Hot-Water Return Piping: White letters on an ANSI Z535.1 safety-green background.
7. Sanitary Waste Piping: White letters on a black background.
8. Storm Drainage Piping: White letters on a black background.
9. Nonpotable Cold Water: Black letters on an ANSI Z535.1 safety-yellow background.
10. Nonpotable Hot Water: Black letters on an ANSI Z535.1-yellow background.
11. Nonpotable Hot-Water Recirculation: Black letters on an ANSI Z535.1-yellow background.
12. Reagent Water Piping: White letters on an ANSI Z535.1 safety-blue background.
13. Deionized Water Piping: White letters on an ANSI Z535.1 safety-blue background.
14. Distilled Water Piping: White letters on an ANSI Z535.1 safety-blue background.
15. Reverse Osmosis Water Piping: White letters on an ANSI Z535.1 safety-blue background.

END OF SECTION 220553

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SECTION 220719
PLUMBING PIPING AND EQUIPMENT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Flexible elastomeric cellular insulation.
- B Flexible removable and reusable blanket insulation.
- C Flexible Glass Fiber Equipment Insulation
- D Rigid Glass Fiber Equipment Insulation
- E Glass fiber pipe insulation.
- F Polyolefin
- G Jacketing and accessories.
- H Under Lavatory Pipe and Supply Covers

1.2 RELATED REQUIREMENTS

- A Division 09 - Exterior Painting: Painting insulation jacket.
- B Division 09 - Interior Painting: Painting insulation jacket.
- C Section 220553 - Identification for Plumbing Piping and Equipment.
- D Section 221005 - Plumbing Piping: Placement of hangers and hanger inserts.

1.3 REFERENCE STANDARDS

- A ASTM A666/A666M - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar; 2024.

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- B ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- C 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).
- D ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2019).
- E ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2007 (Reapproved 2019).
- F ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.
- G ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2023.
- H ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2022a.
- I ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013 (Reapproved 2019).
- J ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2022a.
- K ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014 (Reapproved 2019).
- L ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2023).
- M ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings; 2019 (Reapproved 2022).
- N ASTM C1423 - Standard Guide for Selecting Jacketing Materials for Thermal Insulation; 2021.
- O ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.

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- P ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2023.
- Q SAE AMS3779 - Tape, Adhesive, Pressure-Sensitive Thermal Radiation Resistant, Aluminum Coated Glass Cloth; 2016b.
- R UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A See Division 01 and Division 22 for submittal procedures.
- B Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.5 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section.
- B Applicator Qualifications: Company specializing in performing the type of work specified in this section Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training..

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 FIELD CONDITIONS

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

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PART 2 PRODUCTS

2.1 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.

2.2 FLEXIBLE GLASS FIBER EQUIPMENT INSULATION

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. CertainTeed Corporation
 2. Johns Manville Corporation
 3. Owens Corning Corporation
- B Insulation: ASTM C553; flexible, noncombustible.
1. K (Ksi) Value: 0.24 at 75 degrees F (____ at 24 degrees C), when tested in accordance with ASTM C177 or ASTM C518.
 2. Maximum Service Temperature: 450 degrees F (232 degrees C).
 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C Vapor Barrier Jacket: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
1. Moisture Vapor Permeability: 0.02 perm inch (0.029 ng/(Pa s m)), when tested in accordance with ASTM E96/E96M.
 2. Secure with self-sealing longitudinal laps and butt strips.
 3. Secure with outward clinch expanding staples and vapor barrier mastic.
- D Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.
- E Vapor Barrier Lap Adhesive: Compatible with insulation.
1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- F Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.3 RIGID GLASS FIBER EQUIPMENT INSULATION

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. CertainTeed Corporation

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2. Johns Manville Corporation
3. Owens Corning Corporation

- B Insulation: ASTM C612; rigid, noncombustible.
1. K (Ksi) Value: 0.24 at 75 degrees F (_____ at 24 degrees C), when tested in accordance with ASTM C177 or ASTM C518.
 2. Maximum Service Temperature: 850 degrees F (454 degrees C).
 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
 4. Maximum Density: 8.0 pcf (128 kg/cu m).
- 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 (0.029 ng/(Pa s m)), when tested in accordance with ASTM E96/E96M.
 3. Secure with self-sealing longitudinal laps and butt strips.
 4. Secure with outward clinch expanding staples and vapor barrier mastic.
- D Facing: 1 inch (25 mm) galvanized steel hexagonal wire mesh stitched on one face of insulation.
- E Vapor Barrier Lap Adhesive: Compatible with insulation.
1. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- F Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.4 GLASS FIBER PIPE INSULATION

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. CertainTeed Corporation
 2. Johns Manville Corporation
 3. Knauf Insulation
 4. Owens Corning Corporation
- B Insulation: ASTM C547 and ASTM C795 for application on austenitic Stainless Steel; rigid molded, noncombustible.
1. K (Ksi) Value: ASTM C177, 0.24 at 75 degrees F (0.035 at 24 degrees C).
 2. Maximum Service Temperature: 850 degrees F (454 degrees C).
 3. Maximum Moisture Absorption: 0.2 percent by volume.

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- 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 (0.029 ng/(Pa s m)).
- D Tie Wire: 0.048 inch (1.22 mm) stainless steel with twisted ends on maximum 12 inch (300 mm) centers.
- E Vapor Barrier Lap Adhesive: Compatible with insulation.
- F Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
- G Outdoor Vapor Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- H Outdoor Breather Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- I Insulating Cement: ASTM C449.
- J For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 FLEXIBLE REMOVABLE AND REUSABLE BLANKET INSULATION

- A Insulation: ASTM C553 Type V; flexible, noncombustible.
 - 1. Comply with ASTM C1695.
 - 2. K (Ksi) Value: 0.24 at 75 degrees F (_____ at 24 degrees C), when tested in accordance with ASTM C177 or ASTM C518.
 - 3. Minimum Service Temperature: 32 degrees F (0 degrees C).
 - 4. Maximum Service Temperature: 500 degrees F (260 degrees C).
 - 5. Maximum Water Vapor Absorption: Less than 5.0 percent by weight.
 - 6. Color: Green.
 - 7. Weight: 7.65 oz/sq ft (2334.4 g/sq m).
 - 8. Effective Thickness: 1.25 plus/minus 0.25 inch (0.032 plus/minus 0.0064 m).

2.6 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Aeroflex USA
 - 2. Armacell LLC
 - 3. K-Flex USA LLC

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- 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 (Minus 40 degrees C).
 - 2. Maximum Service Temperature: 220 degrees F (104 degrees C).
 - 3. Connection: Waterproof vapor barrier adhesive.
- C Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.
- D For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E Weather Barrier: Air dried, contact adhesive, compatible with insulation and ASTM E84 compliant.

2.7 POLYOLEFIN

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Aerofoam
 - 2. Thermobreak
- B Indoor
 - 1. Physically cross-linked polyolefin foam with factory applied reinforced aluminum foil.
 - 2. Density: 1.5 pcf (foam core only). Thermal Conductivity : Maximum 0.22 BTU.in/h.ft2. °F @ 73°F mean temperature Water absorption: <0.2 % v/v.
 - 3. Water Vapor permeability (ASTM E96/E96M): Maximum 0.002 perm-inch Service Temperature Range: - 112 °F ~ +212°F Leachable Chlorides (ASTM C871) : < 12 ppm
 - 4. No mold growth when tested to ASTM C1338.
 - 5. Fire Rating : Complies with NFPA 90A and B (ASTM E84 25/50 rating).
- C Outdoor Exposed
 - 1. Physically crosslinked closed cell polyolefin foam with factory applied, heavy duty multilayer composite with a UV and weather durable coating.
 - 2. Water Vapor permeability (ASTM E96): Maximum 0.003 perm-inch
 - 3. Puncture Resistance (ASTM D4833): > 400 N.
 - 4. UV Resistance (ISO 4892-3): No change in performance or appearance after 3000 hours QUV exposure. Density, Conductivity, Water Absorbtion, Temp Range and Fire Rating equal to indoor.

2.8 JACKETING AND ACCESSORIES

- A PVC Plastic Jacket:
 - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.

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- a. Minimum Service Temperature: 0 degrees F (Minus 18 degrees C).
 - b. Maximum Service Temperature: 150 degrees F (66 degrees C).
 - c. Moisture Vapor Permeability: 0.002 perm inch (0.0029 ng/(Pa s m)), maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil, 0.010 inch (0.25 mm).
 - e. Connections: Brush on welding adhesive.
 2. Covering Adhesive Mastic: Compatible with insulation.
- B ABS Plastic Jacket:
1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: Minus 40 degrees F (Minus 40 degrees C).
 - b. Maximum Service Temperature: 180 degrees F (82 degrees C).
 - c. Moisture Vapor Permeability: 0.012 perm inch (0.018 ng/(Pa s m)), when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 30 mil, 0.03 inch (0.75 mm).
 - e. Connections: Brush on welding adhesive.
- C Aluminum Jacket:
1. Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch (0.41 mm) with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
 2. Thickness: 0.016 inch (0.40 mm) sheet.
 3. Finish: Smooth.
 4. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
 5. Fittings: 0.016 inch (0.40 mm) thick die-shaped fitting covers with factory-attached protective liner.
 6. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum or 0.010 inch (0.25 mm) thick stainless steel.
- D Aluminum-Foil Laminate Jacket:
1. Factory-applied, pressure sensitive adhesive jacketing on paper release liner.
 2. Finish: Aluminum smooth.
 3. Comply with ASTM C1775.
- E Stainless Steel Jacket: ASTM A666/A666M, Type 304 stainless steel.
1. Thickness: 0.010 inch (0.25 mm).
 2. Finish: Smooth.
 3. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.010 inch (0.25 mm) thick stainless steel.
- F Reinforced Tape:
1. FSK tape suitable for sealing seams between insulation, insulated pipe bends, 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 (0.00 ng/(Pa s m)), when tested in accordance with ASTM E96/E96M.

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4. Finish: Match insulation.

2.9 UNDER LAVATORY PIPE AND SUPPLY COVERS

A Preformed Insulation Kits

1. Manufacturers:
 - a. IPS Corporation: Truebeo Lav Guard 2
 - b. Plumberex Specialty Products; Handy Shield Maxx
 - c. Zurn Industries, LLC: Trap Wrap
2. Insulate exposed drainage piping and hot, cold, and tempered water supplies under lavatories or sinks per ADA Standards.
 - a. Adhesives, sewing threads, and two-ply laminated materials are prohibited. Exterior Surfaces: Smooth nonabsorbent with no finger recessed indentations for easy cleaning.
 - 1) Construction: PVC with antimicrobial, antifungal, and UV-resistant properties, one piece injected molded design with internal bridge at top of J-bend to prevent separating.
 - 2) Fasteners: Reusable, snap-locking fasteners with no sharp or abrasive external surfaces. No cable ties allowed.
 - 3) Maintenance: Valve and supply cover shall be accessible for maintenance without removal and with removable, reusable access cap.
 - (a) Comply with:
 - (1) ASTM C1822 Type III.
 - (2) ADA Standards

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION - EQUIPMENT

- 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.

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- 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 For fiberglass insulated equipment containing fluids below ambient temperature, provide vapor barrier jackets, factory-applied or field-applied, and finish with glass cloth and vapor barrier adhesive.
- H For hot equipment containing fluids 140 degrees F (60 degrees C) or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
- I For hot equipment containing fluids over 140 degrees F (60 degrees C), insulate flanges and unions with removable sections and jackets.
- J Fiberglass 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.
- K Inserts and Shields:
 - 1. Shields: Galvanized steel between hangers and inserts.
 - 2. Insert location: Between support shield and equipment and under the finish jacket.
 - 3. Insert configuration: Minimum 6 inches (150 mm) long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 4. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- L Finish insulation at supports, protrusions, and interruptions.
- M Exterior Applications:
 - 1. Provide vapor barrier jacket.
 - 2. Cover with aluminum, stainless steel, or _____.
- N Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- O Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

3.3 INSTALLATION - PIPING

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- A Install in accordance with North American Insulation Manufacturers Association (NAIMA) National Insulation Standards.
- B Exposed Piping: Locate insulation and cover seams in least visible locations.
- C Insulated pipes conveying fluids below ambient temperature: 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 (60 degrees C) 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 (60 degrees C), 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 (40 mm) diameter and 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 (150 mm) 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 Division 07.
- J Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet (3 meters) above finished floor): Finish with PVC jacket and fitting covers.

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- K Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Provide factory or field applied cladding. -
1. Minimum 16 mils laminated covering. Puncture resistant, zero permeability, and UV resistant with pressure sensitive adhesive.
- L Buried Piping: Provide factory fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt impregnated open mesh glass fabric, with one mil, 0.001 inch (0.025 mm) thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.
- M Heat Traced Piping: Refer to 220533 - Heat Tracing for Plumbing Piping.

3.4 SCHEDULES

- A General Requirements:
1. Piping installed in wet/humid locations, and piping receiving chilled water/cooling coil condensate waste, shall be insulated with minimum 1 inch (25 mm), and in accordance with the schedules below, thick pre-formed flame-retardant flexible elastomeric cellular pipe insulation installed in accordance with the manufacturer's instructions.
 2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - a. Drainage piping located in crawl spaces.
 - b. Underground piping.
 - c. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
- B Indoor Plumbing Systems:
1. Domestic Hot Water, Hot Water Recirculation, and Tempered Supply:
 - a. Glass Fiber, Polyolefin, or Elastomeric.
 - 1) Pipe Size Range: <1-1/2 inch (<38 mm)
Thickness: 1 inch (25 mm)
 - 2) Pipe Size Range: ≥1-1/2 inch (≥38 mm)
Thickness: 1-1/2 inch (38 mm)
 2. Domestic Cold Water and Non-Potable Cold Water :
 - a. Glass Fiber, Polyolefin, or Elastomeric
 - 1) Pipe Size Range: <1-1/2 inch (38 mm).
Thickness: 1 inch (25 mm).
 - 2) Pipe Size Range: ≥1-1/2 inch (38 mm).
Thickness: 1-1/2 inch (38 mm).
 3. Roof Drain Bodies:
 - a. Glass Fiber, Polyolefin, or Elastomeric
 - 1) Thickness: 1 inch (25 mm)
 4. Primary and Secondary Roof and Storm Drainage: All above grade horizontal piping including first and last fitting connected to a vertical run :
 - a. Glass Fiber, Polyolefin, or Elastomeric

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- 1) Thickness: 1 inch (25 mm)

C Outdoor, Aboveground Piping Insulation Schedule

1. Outdoor Hot Water, Cold Water, Hot Water Recirculation
 - a. Glass Fiber, Polyolefin, or Elastomeric
 - 1) Thickness: 2 inch (50 mm)
 - 2) Provide with field applied jacket: Aluminum - Smooth

D Heating Systems:

1. Pump Bodies:
2. Heat Exchangers/Converters:
3. Air Separators:
4. Expansion Tanks:
5. Hot Thermal Storage Tanks:
6. Boiler Feed Water Storage Tanks:
7. Steam Condensate Receivers:
8. Condensate Tanks:
9. Deaerators:
10. Flue Gas Breeching:
11. Induced Draft Fan Scrolls:
12. Fly Ash Separators:
13. Stacks to Roof:
14. Boiler and Flue Boxes:
15. Boiler Drum Heads:

E Cooling Systems:

1. Pump Bodies:
2. Air Separators:
3. Expansion Tanks:
4. Chiller Cold Surfaces (Not Factory Insulated):
5. Absorption Chiller Hot Surfaces (Not Factory Insulated):
6. Cold Thermal Storage Tanks:
7. Equipment Exposed to Freezing with Heat Tracing:

END OF SECTION 220719

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SECTION 220800

COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.
- B. The OPR and BOD documentation are included by reference for information only.
- C. Division 01 section 'LEED Requirements' for additional LEED requirements.

1.2 SUMMARY

- A. This section includes commissioning process requirements for Plumbing systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. O&M manuals

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F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the contractor for the equipment being tested. For example, the plumbing contractor of Division 22 shall ultimately be responsible for all standard testing equipment for the plumbing system in Division 22, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

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PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. **Red-lined Drawings:** The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. **Operation and Maintenance Data:** Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the contractor.
- D. **Demonstration and Training:** Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meetings.
- C. Attend domestic water balancing review and coordination meetings.
- D. Participate in Plumbing systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- G. Prepare preliminary schedule for Plumbing system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.
- H. Update schedule as required throughout the construction period.
- I. Assist the CxA in all verification and functional performance tests.

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- J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- M. Notify the CxA a minimum of two weeks in advance of the time for start of the balancing work. Attend the initial balancing meeting for review of the balancing procedures.
- N. Participate in, and schedule vendors and contractors to participate in the training sessions.
- O. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Plumbing Piping
 - 2. Medical Gas Piping
 - 3. Domestic Water Storage Tanks
 - 4. Domestic Water Heaters
 - 5. Domestic Water Pumps
 - 6. Domestic Water Booster Pumps
 - 7. Air Compressors
 - 8. Vacuum Pumps
 - 9. RO Systems
 - 10. Nitrogen Generator
- P. The equipment supplier shall document the performance of his equipment.
- Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- R. Balance Contractor
 - 1. Attend initial commissioning coordination meeting scheduled by the CxA.
 - 2. Submit the site specific balancing plan to the CxA and Design Professional for review and acceptance.
 - 3. Attend the balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in balancing the Plumbing system.
 - 4. At the completion of the balancing work, and the submittal of the final balancing report, notify the Plumbing contractor and the CM/GC.
 - 5. At the completion of balancing work, and the submittal of the final balancing report, notify the Plumbing Contractor and the CM/GC.
 - 6. Participate in verification of the balancing report, which will consist of repeating measurements contained in the balancing reports. Assist in diagnostic purposes when directed.
- S. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.

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3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

T. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

A. Certify in writing to the CxA that Plumbing systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify in writing to the CxA that Plumbing instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify in writing that balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 DOMESTIC WATER BALANCING VERIFICATION

A. Prior to performance of Domestic Water Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.

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- B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of Plumbing systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final balancing report.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.8 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Plumbing testing shall include entire Plumbing installation. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the Plumbing contractor, balancing subcontractor shall prepare detailed testing plans, procedures, and checklists for Plumbing systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the Plumbing system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

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3.9 PLUMBING SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 22 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. **Plumbing Instrumentation and Control System Testing:** Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls." Assist the CxA with preparation of testing plans.
- C. **Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment:** Test requirements are specified in Division 22 piping Sections. Plumbing Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. **Plumbing Distribution System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of air, fuel gas, sanitary waste and vent piping, storm drainage piping, sprinkler and domestic water distribution systems.
- E. **Vibration and Sound Tests:** Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.
- F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
 - 1. Plumbing Piping
 - 2. Medical Gas Piping
 - 3. Domestic Water Storage Tanks
 - 4. Domestic Water Heaters
 - 5. Domestic Water Pumps
 - 6. Domestic Water Booster Pumps
 - 7. Air Compressors
 - 8. Vacuum Pumps
 - 9. RO Systems
 - 10. Nitrogen Generator

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- 3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT
- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.
- 3.11 APPROVAL
- A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.
- 3.12 DEFERRED TESTING
- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.
- 3.13 OPERATION AND MAINTENANCE MANUALS
- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section "General Commissioning Requirements" for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.
- 3.14 TRAINING OF OWNER PERSONNEL
- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to training.

END OF SECTION 220800

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SECTION 221005
PLUMBING PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Sanitary waste piping, buried within 5 feet (1500 mm) of building.
- B Sanitary waste piping, above grade.
- C Domestic water piping, buried within 5 feet (1500 mm) of building.
- D Domestic water piping, above grade.
- E Reverse osmosis water piping.
- F Storm drainage piping, buried within 5 feet (1500 mm) of building.
- G Storm drainage piping, above grade.
- H Natural gas piping, buried within 5 feet (1500 mm) of building.
- I Natural gas piping, above grade.
- J Sewage and sump pump discharge piping.
- K Pipe flanges, unions, and couplings.
- L Pipe hangers and supports.
- M Pipe sleeve-seal systems.

1.2 RELATED REQUIREMENTS

- A Section 083100 - NOT OEC EDITED - Access Doors and Panels.
- B Section 220516 - NOT OEC EDITED - Expansion Fittings and Loops for Plumbing Piping.

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- C Section 220529 - Hangers and Supports for Plumbing Piping and Equipment - PENDING APPROVAL.
- D Section 220553 - Identification for Plumbing Piping and Equipment.
- E Section 220719 - Plumbing Piping and Equipment Insulation.

1.3 REFERENCE STANDARDS

- A ANSI LC 1/CSA 6.26 - Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing; 2023.
- B ANSI Z21.22 - American National Standard for Relief Valves for Hot Water Supply Systems; 2015 (Reaffirmed 2020).
- C ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2021.
- D ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2021.
- E ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- F ASME B31.1 - Power Piping; 2024.
- G ASME B31.9 - Building Services Piping; 2020.
- H 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.
- I ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999, with Editorial Revision (2022).
- J ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2022.
- K ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings; 2021.
- L ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.

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- M ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2023a.
- N ASTM B32 - Standard Specification for Solder Metal; 2020.
- O ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.
- P ASTM B813 - Standard Specification for Water Flushable Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube; 2024.
- Q ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings; 2023.
- R ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings; 2020a.
- S ASTM C1277 - Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings; 2020.
- T ASTM C1540 - Standard Specification for Heavy-Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings; 2020.
- U ASTM D2239 - Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter; 2022.
- V ASTM D2609 - Standard Specification for Plastic Insert Fittings for Polyethylene (PE) Plastic Pipe; 2021.
- W 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.
- X ASTM D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings; 2023.
- Y ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- Z AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems; 2018.
- AA AWWA C606 - Grooved and Shouldered Joints; 2022.

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- BB AWWA C651 - Disinfecting Water Mains; 2023.
- CC CISPI 301 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications; 2021.
- DD 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.
- EE FM 1680 - Approval Standard for Couplings Used in Hubless Cast Iron Systems for Drain, Waste or Vent, Sewer, Rainwater or Storm Drain Systems Above and Below Ground, Industrial/ Commercial and Residential; 1989.
- FF ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements; 2018, with Editorial Revision (2020).
- GG ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry; 2018, with Editorial Revision (2020).
- HH ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements; 2017, with Editorial Revision (2020).
- II ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements; 2023.
- JJ MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2018, with Amendment (2019).
- KK NSF 61 - Drinking Water System Components - Health Effects; 2024.
- LL NSF 372 - Drinking Water System Components - Lead Content; 2024.
- MM UL (DIR) - Online Certifications Directory; Current Edition.
- NN UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A See Division 01 and Section 220500 for submittal procedure.

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- B Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- C Welders' Certificates: Submit certification of welders' compliance with ASME BPVC-IX.
- D Shop Drawings: For non-penetrating rooftop supports, submit detailed layout developed for this project, with design calculations for loadings and spacings.
- E Sustainable Design Documentation: For soldered copper joints, submit installer's certification that the specified installation method and materials were used.
- F Sustainable Design Documentation: For products meeting regulatory lead-content restrictions.
- G Project Record Documents: Record actual locations of valves.
- H Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - NOT OEC EDITED - Product Requirements for additional provisions.
 - 2. Valve Repacking Kits: One for each type and size of valve.

1.5 QUALITY ASSURANCE

- A Perform work in accordance with applicable codes.
- B Valves: Manufacturer's name and pressure rating marked on valve body.
- C Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.
- D Welder Qualifications: Certified in accordance with ASME BPVC-IX.
- E Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B Provide temporary protective coating on cast iron and steel valves.

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

1.7 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.1 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 Solvent Cement and Adhesive Primer:
 - 1. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.2 SANITARY WASTE PIPING, ABOVE GRADE

- A Cast Iron Pipe: ASTM A74, service weight.
 - 1. Fittings: Cast iron.
 - 2. Joint Seals: ASTM C564 neoprene gaskets. .
- B 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.

2.3 DOMESTIC WATER PIPING, BURIED WITHIN 5 FEET (1500 MM) OF BUILDING

- A Copper Pipe: ASTM B88 (ASTM B88M), Type K (A), 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.
 - 3. Joints: Grooved mechanical couplings.

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2.4 DOMESTIC WATER PIPING, ABOVE GRADE

- A Copper Pipe: 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.
 - 3. Joints: Press joint fittings.
 - 4. Mechanical Press Sealed Fittings: Double-pressed type, NSF 61 and NSF 372 approved or certified, utilizing EPDM, nontoxic, synthetic rubber sealing elements.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) Anvil International
 - 2) Apollo Valves
 - 3) FNW
 - 4) Grinnell Products
 - 5) Viega LLC;
- B NON-POTABLE WATER PIPING
 - 1. Copper Pipe: ASTM B88 (ASTM B88M), Type L (B), Drawn (H).
 - a. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 - b. Joints: ASTM B32, alloy Sn95 solder.
 - c. Joints: Grooved mechanical couplings.
 - d. Mechanical Press Sealed Fittings: Double-pressed type, NSF 61 and NSF 372 approved or certified, utilizing EPDM, nontoxic, synthetic rubber sealing elements.
 - 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - (a) Anvil International
 - (b) Apollo Valves
 - (c) FNW
 - (d) Grinnell Products
 - (e) Viega LLC;
- C REVERSE OSMOSIS WATER PIPING - LAB WATER QUALITY 2
 - 1. PE Pipe: ASTM D2239. (per approved manufacturer's standard)
 - a. Fittings: ASTM D2609, PE. (per approved manufacturer's standard)
 - b. Joints: Mechanical with stainless steel clamp.
 - c. Joints: Butt fusion welded or socket fusion welded per approved manufacturer.

2.5 STORM DRAINAGE PIPING, ABOVE GRADE

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

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- B Cast Iron Pipe: CISPI 301, hubless, service weight.
 - 1. Fittings: Cast iron.
 - 2. Joints: Neoprene gaskets and stainless steel clamp-and-shield assemblies.

2.6 NATURAL GAS PIPING, BURIED WITHIN 5 FEET (1500 MM) OF BUILDING

- A Steel Pipe: ASTM A53/A53M, Grade B, Type F, Schedule 40 black.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Wheatland Tube Company
 - 2. Fittings: ASTM A234/A234M, wrought steel welding type.
 - 3. Joints: ASME B31.1, welded.
 - 4. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil (0.25 mm) polyethylene tape.

2.7 NATURAL GAS PIPING, ABOVE GRADE

- A Steel Pipe: ASTM A53/A53M Schedule 40 black.
 - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: Threaded or welded to ASME B31.1.
- B Flexible Gas Piping:
 - 1. Corrugated Stainless Steel Tubing: Comply with ANSI LC 1/CSA 6.26.
 - 2. Comply with ASTM E84.
 - 3. Fittings: Provided by piping system manufacturer.
 - 4. Provide piping with integral lightning protection.
 - 5. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Omega Flex, Inc

2.8 SEWAGE AND SUMP PUMP DISCHARGE PIPING

- A Steel Pipe: ASTM A53/A53M Schedule 40 black.
 - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: Threaded or welded to ASME B31.1.
- B PVC Pipe: ASTM D1785 or ASTM D2241.
 - 1. Fittings: ASTM D2665, PVC.
 - 2. Joints: ASTM D2846/D2846M, solvent weld with ASTM F493 solvent cement.

2.9 PIPE FLANGES, UNIONS, AND COUPLINGS

- A Unions for Pipe Sizes 3 inch (80 mm, DN) and Under:

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1. Ferrous Pipe: Class 150 malleable iron threaded unions.
 2. Copper Tube and Pipe: Class 150 bronze unions with soldered joints.
- B Flanges for Pipe Sizes Over 1 inch (25 mm, DN):
1. Ferrous Pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
 2. Copper Tube and Pipe: Class 150 slip-on bronze flanges; preformed neoprene gaskets.
- 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. Housing Material: Provide ASTM A47/A47M malleable iron, ductile iron, or _____, galvanized.
 3. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F (minus 34 degrees C) to 230 degrees F (110 degrees C).
 4. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
 5. When pipe is field grooved, provide coupling manufacturer's grooving tools.
 6. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Anvil International
 - b. Victaulic
- D No-Hub Couplings:
1. Testing: In accordance with ASTM C1277 and CISPI 310.
 2. Gasket Material: Neoprene complying with ASTM C564.
 3. Band Material: Stainless steel.
 4. Eyelet Material: Stainless steel.
 5. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Ideal Clamp Products, Inc; Standard: .
 - b. MIFAB, Inc; MI-QHUB:
- E Shielded, Heavy Duty No-Hub Couplings:
1. Testing: In accordance with ASTM C1540 and FM 1680.
 2. Gasket Material: Neoprene complying with ASTM C564.
 3. Band Material: Stainless steel.
 4. Eyelet Material: Stainless steel.
 5. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Ideal Clamp Products, Inc
 - b. MIFAB, Inc
- F Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

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2.10 PIPE HANGERS AND SUPPORTS

- A See Section 220529 for additional requirements.
- B 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. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
 - a. Cold and Hot Pipe Sizes 6 inch (150 mm, DN) and Larger: Double hangers.
 3. Trapeze Hangers: Welded steel channel frames attached to structure.
 4. Vertical Pipe Support: Steel riser clamp.
 5. Floor Supports: Concrete pier or steel pedestal with floor flange; fixture attachment.
 6. 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 polypropylene.
 - 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 and 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 (150 mm) under pipe to top of roofing.
 - f. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) PHP Systems/Design
- C Plumbing Piping - Drain, Waste, and Vent:
1. Hangers for Pipe Sizes 1/2 to 1-1/2 inch (15 to 40 mm, DN): Malleable iron, adjustable swivel, split ring.
 2. Hangers for Pipe Sizes 2 inch (50 mm, DN) and Over: Carbon steel, adjustable, clevis.
 3. Wall Support for Pipe Sizes to 3 inch (80 mm, DN): Cast iron hook.
 4. Wall Support for Pipe Sizes 4 inch (100 mm, DN) and Over: Welded steel bracket and wrought steel clamp.
 5. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- D Plumbing Piping - Water:
1. Hangers for Pipe Sizes 1/2 to 1-1/2 inch (15 to 40 mm, DN): Malleable iron, adjustable swivel, split ring.
 2. Hangers for Cold Pipe Sizes 2 inch (50 mm, DN) and Over: Carbon steel, adjustable, clevis.

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3. Hangers for Hot Pipe Sizes 2 to 4 inch (50 to 100 mm, DN): Carbon steel, adjustable, clevis.
 4. Hangers for Hot Pipe Sizes 6 inch (150 mm, DN) and Larger: Adjustable steel yoke, cast iron pipe roll, double hanger.
 5. Wall Support for Pipe Sizes Up to 3 inch (80 mm, DN): Cast iron hook.
 6. Wall Support for Pipe Sizes 4 inch (100 mm, DN) and Larger: Welded steel bracket and wrought steel clamp.
 7. Wall Support for Hot Pipe Sizes 6 inch (150 mm, DN) and Larger: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron pipe roll.
 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 inch (100 mm, DN): Cast iron adjustable pipe saddle, locknut, nipple, floor flange, and concrete pier or steel support.
 10. Floor Support for Hot Pipe Sizes 6 inch (150 mm, DN) and Larger: Adjustable cast iron pipe roll and stand, steel screws, and concrete pier or steel support.
 11. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- E Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
1. Concrete Wedge Expansion Anchors: Comply with ICC-ES AC193.
 2. Masonry Wedge Expansion Anchors: Comply with ICC-ES AC01.
 3. Concrete Screw Type Anchors: Comply with ICC-ES AC193.
 4. Masonry Screw Type Anchors: Comply with ICC-ES AC106.
 5. Concrete Adhesive Type Anchors: Comply with ICC-ES AC308.
 6. Other Types: As required.
 7. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Powers Fasteners, Inc

2.11 PIPE SLEEVE-SEAL SYSTEMS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. BMW Company
 2. GPT, a company of Enpro Industries, Inc
 3. The Metraflex Company
- B Modular Mechanical Seals:
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 to service requirements.
 4. Service Requirements:
 - a. Corrosion resistant.
 - b. Oil, fuel, gas, and solvent resistant.
 - c. Underground, buried, and wet conditions.
 - d. Fire Resistant: 1 hour, UL (DIR) approved.

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- e. High Temperature, up to 400 deg F (204 deg C).
- f. Low temperature, down to minus 67 deg F (minus 55 deg C).
- 5. Glass reinforced plastic pressure end plates.

C Wall Sleeve: PVC material with water-stop collar, and nailer end-caps.

D Sleeve-Forming Disk: Non-conductive plastic-based material, 3 inch (76.2 mm) thick.

E Pipeline-Casing Seals:

- 1. Coated metallic boltless casing-spacer for 4 inch (100 mm) carrier pipe.
- 2. Coated metallic boltless modular seal for 6 inch (150 mm) carrier pipe.
- 3. Carbon steel band with risers for 12 inch (305 mm) carrier pipe.
- 4. End Seals: 1/8 inch (3.1 mm), pull-on type, rubber or synthetic rubber based.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 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.

3.3 INSTALLATION

A Install in accordance with manufacturer's instructions.

B Provide non-conducting dielectric connections wherever jointing dissimilar metals.

C Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.

D Install piping to maintain headroom, conserve space, and not interfere with use of space.

E Group piping whenever practical at common elevations.

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- F Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. See Section 220516.
- G Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
 - 1. See Section 220719.
- H Provide access where valves and fittings are not exposed.
 - 1. Coordinate size and location of access doors with Section 083100.
- I Establish elevations of buried piping outside the building to ensure not less than _____ ft (_____ m) of cover.
- J Install vent piping penetrating roofed areas to maintain integrity of roof assembly; see Section _____.
- K Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welding.
- L Provide support for utility meters in accordance with requirements of utility companies.
- M Prepare exposed, unfinished pipe, fittings, supports, and accessories for finish painting.
 - 1. See Section 099123 for painting of interior plumbing systems and components.
 - 2. See Section 099113 for painting of exterior plumbing systems and components.
- N Excavate in accordance with Section 312316.
- O Backfill in accordance with Section 312323.
- P Install bell and spigot pipe with bell end upstream.
- Q Install valves with stems upright or horizontal, not inverted. See Section 220523.
- R Install water piping to ASME B31.9.
- S 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.
- T PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.

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- U PVC piping may not be installed in a return air plenum for any above grade piping applications.
- V Sleeve pipes passing through partitions, walls, and floors.
- W 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 (100 mm, DN).
 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.
- X Pipe Hangers and Supports:
1. Install in accordance with ASME B31.9.
 2. Support horizontal piping as indicated.
 3. Install hangers to provide minimum 1/2 inch (15 mm) space between finished covering and adjacent work.
 4. Place hangers within 12 inches (300 mm) of each horizontal elbow.
 5. Use hangers with 1-1/2 inch (40 mm) 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. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
 - a. Painting of interior plumbing systems and components is specified in Section 099123.
 - b. Painting of exterior plumbing systems and components is specified in Section 099113.
 10. Provide hangers adjacent to motor-driven equipment with vibration isolation; see Section 220548.
 11. Support cast iron drainage piping at every joint.
- Y 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.

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- Z 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.

3.4 APPLICATION

- A Use grooved mechanical couplings and fasteners only in accessible locations.
- B Install unions downstream of valves and at equipment or apparatus connections.
- C Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- D Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- E Install ball valves for throttling, bypass, or manual flow control services.
- F Provide lug end butterfly valves adjacent to equipment when provided to isolate equipment.
- G Provide spring-loaded check valves on discharge of water pumps.
- H Provide flow controls in water recirculating systems where indicated.

3.5 TOLERANCES

- A Drainage Piping: Establish invert elevations within 1/2 inch (10 mm) vertically of location indicated and slope to drain at minimum of 1/8 inch per foot (1:100) slope.
- B Water Piping: Slope at minimum of 1/32 inch per foot (1:400) and arrange to drain at low points.

3.6 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 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:

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- a. Fill the system with water and raise static head to 10 psi (345 kPa) above service pressure. Minimum static head of 50 to 150 psi (345 to 1,034 kPa). As an exception, certain codes allow a maximum static pressure of 80 psi (551.6 kPa).
- 4. Metal Piping Systems Subject to Freezing Conditions:
 - a. Inject 40 psi (275.8 kPa) of compressed air into piping to spot check for leaks with liquid soap. Document and repair leaks as necessary.
 - b. Raise injected compressed air pressure to 1.5 times rated service pressure or minimum pressure of 100 psi (689.5 kPa) for a duration of 2 hours and verify with a gauge that no perceptible pressure drop is measured.
- C Gas Distribution Systems:
 - 1. Test Preparation: Close each appliance valve or disconnect and cap each connected appliance.
 - 2. General Systems:
 - a. Inject a minimum of 10 psi (68.9 kPa) of compressed air into the piping system for a duration of 15 minutes and verify with a gauge that no perceptible pressure drop is measured.
 - b. Ensure test pressure gauge has a range of twice the specific pressure rate selected with an accuracy of 1/10 of 1 pound (0.45 kg).
 - 3. Welded Pipes or Systems with Service Pressures Above 14 in-wc (3.48 kPa):
 - a. Inject a minimum of 60 psi (413.7 kPa) of compressed air into the piping system for a duration of 30 minutes and verify with a gauge that no perceptible pressure drop is measured.
 - b. Ensure test pressure gauge has a range of twice the specific pressure rate selected with an accuracy of 1/10 of 1 pound (0.45 kg) with 1 psi (6.9 kPa) increments.
- D Test Results: Document and certify successful results, otherwise repair, document, and retest.

3.7 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A Disinfect water distribution system in accordance with Section 330110.58.
- B Prior to starting work, verify system is complete, flushed, and clean.
- C 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).
- D Inject disinfectant, free chlorine in liquid, powder, tablet, or gas form throughout system to obtain 50 to 80 mg/L residual.
- E Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- F Maintain disinfectant in system for 24 hours.

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- G If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- H Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
- I 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.

3.8 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.
 - 2. Provide 18 gauge, 0.0478-inch (1.21 mm) galvanized sheet metal sleeve around service main to 6 inch (150 mm) above floor and 6 feet (1800 mm) minimum below grade. Size for minimum of 2 inches (50 mm) of loose batt insulation stuffing.

3.9 SCHEDULES

- A Pipe Hanger Spacing:
 - 1. Metal Piping:
 - a. Pipe Size: 1/2 inch (15 mm, DN) to 1-1/4 inch (32 mm, DN):
 - 1) Maximum Hanger Spacing: 6.5 ft (2 m).
 - 2) Hanger Rod Diameter: 3/8 inches (9 mm).
 - b. Pipe Size: 1-1/2 inch (40 mm, DN) to 2 inch (50 mm, DN):
 - 1) Maximum Hanger Spacing: 10 ft (3 m).
 - 2) Hanger Rod Diameter: 3/8 inch (9 mm).
 - c. Pipe Size: 2-1/2 inch (65 mm, DN) to 3 inch (80 mm, DN):
 - 1) Maximum Hanger Spacing: 10 ft (3 m).
 - 2) Hanger Rod Diameter: 1/2 inch (13 mm).
 - d. Pipe Size: 4 inch (100 mm, DN) to 6 inch (150 mm, DN):
 - 1) Maximum Hanger Spacing: 10 ft (3 m).
 - 2) Hanger Rod Diameter: 5/8 inch (15 mm).
 - e. Pipe Size: 8 inch (200 mm, DN) to 12 inch (300 mm, DN):
 - 1) Maximum hanger spacing: 14 ft (4.25 m).
 - 2) Hanger Rod Diameter: 7/8 inch (22 mm).
 - f. Pipe Size: 14 inch and Over (350 mm, DN and Over):
 - 1) Maximum Hanger Spacing: 20 ft (6 m).

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- 2) Hanger Rod Diameter: 1 inch (25 mm).
- 2. Plastic Piping:
 - a. All Sizes:
 - 1) Maximum Hanger Spacing: 6 ft (1.8 m).
 - 2) Hanger Rod Diameter: 3/8 inch (9 mm).

END OF SECTION 221005

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SECTION 221006
PLUMBING PIPING SPECIALTIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Drains.
- B Cleanouts.
- C Hose bibbs.
- D Ice maker outlet boxes.
- E Backwater valves.
- F Backflow preventers.
- G Double check valve assemblies.
- H Water hammer arrestors.
- I Mixing valves.
- J Relief valves.
- K Air vents.
- L Floor drain trap seals.
- M Electronic trap-seal primers.
- N Exterior penetration accessories.
- O Strainers.
- P Pressure Reducing Valves.

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Q Balance valves.

1.2 REFERENCE STANDARDS

- A ADA Standards - 2010 ADA Standards for Accessible Design; 2010.
- B ASME A112.6.3 - Floor Drains; 2022.
- C ASME A112.6.4 - Roof, Deck, and Balcony Drains; 2022.
- D ASME A112.6.9 - Siphonic Roof Drains; 2005 (Reaffirmed 2019).
- E ASSE 1012 - Performance Requirements for Backflow Preventers with an Intermediate Atmospheric Vent; 2021.
- F ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies; 2021.
- G ASSE 1015 - Performance Requirements for Double Check Backflow Prevention Assemblies; 2021.
- H ASSE 1047 - Performance Requirements for Reduced Pressure Detector Backflow Prevention Assemblies; 2021.
- I ASSE 1048 - Performance Requirements for Double Check Detector Backflow Prevention Assemblies; 2021e.
- J ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices; 2020.
- K NSF 61 - Drinking Water System Components - Health Effects; 2024.
- L NSF 372 - Drinking Water System Components - Lead Content; 2024.
- M PDI-WH 201 - Water Hammer Arresters; 2017.

1.3 SUBMITTALS

- A Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- B Certificates: Certify that grease interceptors meet or exceed specified requirements.

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- C Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- D Sustainable Design Documentation: Submit appropriate evidence that materials used in potable water systems comply with the specified requirements.
- E Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- F Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Loose Keys for Outside Wall Hydrant or Hose Bibbs: One.
 - 2. Extra Hose End Vacuum Breakers for Wall Hydrants or Hose Bibbs: One.

1.4 QUALITY ASSURANCE

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

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

2.2 DRAINS

- A Manufacturers:
 - 1. Jay R. Smith Manufacturing Company
 - 2. Josam Company
 - 3. MIFAB, Inc
 - 4. Wade Specification Drainage Products
 - 5. Zurn Industries, LLC
- B Roof Drains (RD):
 - 1. Assembly: ASME A112.6.4.
 - 2. Refer to schedule on drawings.

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- C Roof Overflow Drains (ERD):
 - 1. Assembly: ASME A112.6.4
 - 2. Refer to schedule on drawings.
 - a. Drain to match primary roof drain characteristics.
- D Downspout Nozzles (ESO):
 - 1. Nickel-Bronze round with straight bottom section.
- E Floor Drains (FD):
 - 1. Assembly: ASME A112.6.3
 - 2. Refer to schedule on drawings.
- F Shower Drain (SD):
 - 1. Assembly: ASME A112.6.3
 - 2. Refer to schedule on drawings.
- G Trench Drain (TD):
 - 1. Assembly: ASME A112.6.3
 - 2. Refer to schedule on drawings.
- H Floor Sinks (FS):
 - 1. Assembly: ASME A112.6.7
 - 2. Refer to schedule on drawings.

2.3 CLEANOUTS

- A Manufacturers:
 - 1. Jay R. Smith Manufacturing Company:
 - 2. Josam Company:
 - 3. MIFAB, Inc:
 - 4. Tyler Pipe, Wade Division:
 - 5. Zurn Industries, LLC:
- B Floor Cleanout (FCO):
 - 1. Assembly: ASME A112.36.2
 - 2. Refer to schedule on drawings.
- C Grade Cleanout (GCO) :
 - 1. Assembly: ASME A112.36.2
 - 2. Refer to schedule on drawings.
- D Wall Cleanout (WCO):

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1. Assembly: ASME A112.36.2
2. Refer to schedule on drawings.

2.4 HOSE BIBBS

- A Manufacturers:
1. Arrowhead Brass Products, Inc:
 2. Jay R. Smith Manufacturing Company:
 3. Watts Regulator Company:
 4. Woodford Manufacturing Co.
 5. Zurn Industries, LLC: .
- B Interior Hose Bibbs:
1. Assembly: ASME A112.18.1
 2. Refer to schedule on drawings.

2.5 ICE MAKER OUTLET BOXES

- A Manufacturers:
1. IPS Corporation/Water-Tite; ____:
 2. Oatey Supply Chain Services, Inc; ____:
 3. Zurn Industries, LLC; ____:
- B Assembly: ASME A112.18.1
- C Refer to schedule on drawings.

2.6 BACKWATER VALVES

- A Cast Iron Backwater Valve (BWV)
1. Manufacturers:
 - a. Jay R. Smith Manufacturing Company:
 - b. Josam Company
 - c. Zurn Industries, LLC
 2. Assembly: ASME A112.14.1
 3. Refer to schedule on drawings.
- B Plastic Backwater Valves(BWV)
1. Manufacturers:
 - a. Oatey Supply Chain Services, Inc
 - b. RectorSeal Corporation, a CSW Industrials Company
 - c. Zurn Industries, LLC

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2. Assembly: ASME A112.6.14.1
3. Refer to schedule on drawings.

2.7 BACKFLOW PREVENTERS

A Manufacturers:

1. Apollo Valves
2. MIFAB, Inc
3. Watts Regulator Company, a part of Watts Water Technologies
4. Zurn Industries, LLC

B Reduced Pressure Backflow Preventer Assembly:

1. ASSE 1013; cast bronze 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, and non-threaded vent outlet.
2. Size: 3/4 to 2 inch (20 to 50 mm, DN) assembly with threaded full port ball valves.
3. Maximum Working Parameters: 175 psi (1,207 kPa) at 180 degrees F (82.2 degrees C).
4. Accessories: Provide air gap fitting, lead-free Y-strainer, and test cocks.

C Reduced Pressure Backflow Preventer Assembly:

1. ASSE 1013 and NSF 61 compliant stainless steel body assembly with corrosion resistant internal parts, stainless steel springs, diaphragm type differential pressure relief valve located between check valves, third check valve that opens under back pressure in case of diaphragm failure, and non-threaded vent outlet.
2. Configured to protect against backsiphonage and backpressure into potable water supply.
3. Size: 2-1/2 to 10 inch (65 to 250 mm, DN) assembly with flanged NRS gate valves.
4. Maximum Working Parameters: 175 psi (1,207 kPa) at 140 degrees F (60 degrees C).
5. Accessories: Provide flanged Y-strainer, pressure monitor, and test cock.

D Reduced Pressure Backflow Detector Assembly:

1. ASSE 1047 and NSF 61 compliant stainless steel body assembly with metered by-pass, corrosion resistant internal parts, stainless steel springs, diaphragm type differential pressure relief valve located between check valves, third check valve that opens under back pressure in case of diaphragm failure, and non-threaded vent outlet.
2. Configured to protect against backsiphonage and backpressure into potable water supply.
3. Size: 2-1/2 to 10 inch (65 to 250 mm, DN) assembly with flanged OS&Y gate valves.
4. Maximum Working Parameters: 175 psi (1,207 kPa) at 140 degrees F (60 degrees C).
5. Accessories: Provide flanged Y-strainer, remote reader for meter, and test cock.

2.8 DOUBLE CHECK-VALVE ASSEMBLIES

A Manufacturers:

1. Apollo Valves:

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2. MIFAB, Inc:
3. Watts Regulator Company, a part of Watts Water Technologies:
4. Zurn Industries, LLC:

B Double Check Valve Assembly:

1. ASSE 1012; cast bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.
2. Size: 3/4 to 2 inch, NPS (20 to 50 mm, DN) assembly with threaded full port ball valves.
3. Maximum Working Parameters: 175 psi (1,207 kPa) at 180 degrees F (82.2 degrees C).
4. Accessories: Provide lead-free Y-strainer and pit-mounted protective enclosure.

C Double Check Valve Assembly:

1. ASSE 1015 and NSF 61 compliant cast bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.
2. Size: 3/4 to 2 inch, NPS (20 to 50 mm, DN) assembly with threaded full port ball valves.
3. Maximum Working Parameters: 175 psi (1,207 kPa) at 180 degrees F (82.2 degrees C).
4. Accessories: Provide lead-free Y-strainer and pit-mounted protective enclosure.

D Double Check Valve Assembly:

1. ASSE 1015 and NSF 61 compliant bronze body assembly with corrosion resistant internal parts, stainless steel springs, intermediate atmospheric vent, two independently-operating check valves, and test-cock plug for horizontal or vertical mount.
2. Size: 3/4 to 2 inch, NPS (20 to 50 mm, DN) assembly with threaded full port ball valves.
3. Maximum Working Parameters: 175 psi (1,207 kPa) at 180 degrees F (82.2 degrees C).
4. Accessories: Provide lead-free Y-strainer and pit-mounted protective enclosure.

E Double Check Valve Assembly:

1. ASSE 1015 and NSF 61 compliant stainless steel body assembly with corrosion resistant internal parts, stainless steel springs, intermediate atmospheric vent, two independently-operating check valves, and test-cock plug for horizontal or vertical mount.
2. Configured to protect against backsiphonage and backpressure into potable water supply.
3. Size: 2-1/2 to 10 inch (65 to 250 mm, DN) assembly with flanged OS&Y gate valves.
4. Maximum Working Parameters: 175 psi (1,207 kPa) at 140 degrees F (60 degrees C).
5. Accessories: Provide flanged Y-strainer and test cock.

F Double Check Detector Assemblies:

1. ASSE 1048 and NSF 61 compliant stainless steel body assembly with metered by-pass, corrosion resistant internal parts, stainless steel springs, intermediate atmospheric vent, two independently-operating check valves, and test-cock plug for horizontal or vertical mount.
2. Configured to protect against backsiphonage and backpressure into potable water supply.
3. Size: _____ inch (_____ mm, DN) assembly with flanged OS&Y gate valves.
4. Maximum Working Parameters: 175 psi (1,207 kPa) at 140 degrees F (60 degrees C).
5. Accessories: Provide flanged Y-strainer, remote reader for meter, and test cock.

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2.9 WATER HAMMER ARRESTORS

- A Manufacturers:
 - 1. Cash Acme, a brand of Reliance Worldwide Corporation
 - 2. Jay R. Smith Manufacturing Company
 - 3. Watts Regulator Company, a part of Watts Water Technologies
 - 4. Zurn Industries, LLC
- B Water Hammer Arrestors:
 - 1. Stainless steel construction, bellows type sized in accordance with PDI-WH 201, precharged suitable for operation in temperature range minus 100 to 300 degrees F (minus 73 to 149 degrees C) and maximum 250 psi (1700 kPa) working pressure.

2.10 SUMP BASINS

- A Manufacturers:
 - 1. Liberty Pumps
 - 2. Topp Industries, Inc
 - 3. Zoeller Company
- B Glass fiber reinforced with required openings and drainage fittings.
- C Cover: 3/8 inch (9 mm) thick checkered steel plate with gasket seal frames and anchor bolts.
- D Dimensions: Refer to schedule on drawings.
- E Capacity: Refer to schedule on drawings.

2.11 MIXING VALVES

- A Water Temperature Limiting Valves: Point of Use Handwashing (TMV)
 - 1. Manufacturers:
 - a. Leonard Valve Company
 - b. Watts Water Technologies; Bradley
 - c. Watts Water Technologies; POWERS
 - 2. Valve: ASSE 1070, bronze or brass body; thermostatic element; corrosion- and lime-resistant internal components; integral locking temperature adjustment with high-temperature limit stop; integral check valves with strainer screens on inlets.
 - 3. Capacity: Refer to schedule on drawings.

2.12 RELIEF VALVES

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- A Manufacturers:
 - 1. Cash Acme, a brand of Reliance Worldwide Corporation
 - 2. ITT Bell & Gossett
 - 3. Watts Water Technologies

- B Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

2.13 AIR VENTS

- A Manufacturers:
 - 1. Cash Acme, a brand of Reliance Worldwide Corporation
 - 2. ITT Bell & Gossett
 - 3. Taco, Inc
 - 4. Watts Water Technologies

- B Manual Type: Short vertical sections of 2 inch (50 mm) diameter pipe to form air chamber, with 1/8 inch (3 mm) brass needle valve at top of chamber.

2.14 FLOOR DRAIN TRAP SEALS

- A Manufacturers:
 - 1. Green Drains; GD4:
 - 2. Jay. R. Smith Manufacturing Co; 2692
 - 3. MIFAB, Inc; MI-GARD:
 - 4. Zurn Industries, LLC ; Z1072

- B Assembly: Complies with ASSE 1072.

- C Description: Push-fit EPDM or silicone fitting with a one-way membrane.

2.15 ELECTRONIC TRAP-SEAL PRIMERS

- A Manufacturers:
 - 1. MIFAB, Inc
 - 2. Precision Plumbing Products
 - 3. Zurn Industries, LLC

- B Description: Enclosed electronic trap seal primer system with timer.

2.16 EXTERIOR PENETRATION ACCESSORIES

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- A 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.
- B Sealing Systems for Roof Penetrations: Premanufactured components and accessories as required to preserve integrity of roofing system and maintain roof warranty; suitable for piping, cables, and roofing system to be installed; designed to accommodate existing penetrations where applicable.

2.17 STRAINERS

- A Manufacturers:
 - 1. Armstrong International, Inc
 - 2. Green Country Filter Manufacturing
 - 3. Watts Water Technologies
 - 4. WEAMCO
- B Size 1/2 inch (15 mm, DN) to 3 inch (80 mm, DN):
 - 1. Class 150, threaded forged bronze Y-pattern body, stainless steel perforated mesh screen with cap, and rated for 150 psi (1,034 kPa), 250 deg F (121.1 deg C) WOG service.
- C Size 2 inch (50 mm, DN) and Smaller:
 - 1. Threaded brass body for 175 psi (1200 kPa) CWP, Y pattern with 1/32 inch (0.8 mm) stainless steel perforated screen.
 - 2. Class 150, threaded bronze body 300 psi (2070 kPa) CWP, Y pattern with 1/32 inch (0.8 mm) stainless steel perforated screen.
- D Size 1-1/2 inch (40 mm, DN) to 4 inch (100 mm, DN):
 - 1. Class 125, flanged iron body, Y pattern with 1/16 inch (1.6 mm) stainless steel perforated screen.
- E Size 5 inch (125 mm, DN) and Larger:
 - 1. Class 125, flanged iron body, basket pattern with 1/8 inch (3.2 mm) stainless steel perforated screen.

2.18 PRESSURE REDUCING VALVES

- A Manufacturers:
 - 1. American Wheatley, a company of Global Flow Products, LLC
 - 2. Apollo Valves
 - 3. Armstrong International, Inc
 - 4. Bell & Gossett, a brand of Xylem, Inc
 - 5. Taco, Inc

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- 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.
- D Provide integral check valve and strainer.
- E Maximum Inlet Pressure: 400 psi (2,758 kPa).
- F Maximum Fluid Temperature: 180 degrees F (82 degrees C).
- G Adjustable Pressure Range: From 10 to 45 psi (69 to 310.3 kPa), set to 25 psi (172 kPa).

2.19 BALANCING VALVES

- A Manufacturers: Subject to compliance with requirements, provide products from one of the following or an approved equal.
 - 1. Armstrong International, Inc
 - 2. Bell & Gossett, a brand of Xylem, Inc
 - 3. Nexus Valve, Inc
 - 4. Taco, Inc
 - 5. Nibco, Inc.
 - 6. Tour & Anderson; available through Victaulic Company of America.
- B Size 2 inch (50 mm, DN) and Smaller:
 - 1. Provide ball or globe style with flow balancing, shut-off capabilities, memory stops, and minimum of two metering ports and NPT threaded, press, or soldered connections.
 - 2. Metal construction materials consist of bronze or brass.
 - 3. Non-metal construction materials consist of Teflon or EPDM.
 - 4. Maximum Service Operation: 255 psi at 240 degrees F (1,551 kPa at 115.6 degrees C).

PART 3 EXECUTION

3.1 INSTALLATION

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

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- C Encase exterior cleanouts in concrete flush with grade.
- 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.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- 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, flush valves, or ____.
- H Install balancing valves in locations where they can be easily adjusted.
- I ADJUSTING
 - 1. Set field-adjustable pressure set points of water pressure-reducing valves.
 - 2. Set field-adjustable flow of balancing valves.
 - 3. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 221006

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SECTION 221123
DOMESTIC WATER PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Circulators.
- B Inline pumps.
- C Pressure booster systems.

1.2 RELATED REQUIREMENTS

- A Section 220513 - Common Motor Requirements for Plumbing Equipment.
- B Section 260583 - NOT OEC EDITED - Wiring Connections.

1.3 REFERENCE STANDARDS

- A ANSI/HI 1.4 - Rotodynamic Centrifugal Pumps for Manuals Describing Installation, Operation, and Maintenance; 2014.
- B ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).
- C ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.
- D ASME B31.9 - Building Services Piping; 2020.
- E ICC (IPC) - International Plumbing Code; 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 NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

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- H NSF 61 - Drinking Water System Components - Health Effects; 2024.
- I NSF 372 - Drinking Water System Components - Lead Content; 2024.
- J UL 508 - Industrial Control Equipment; Current Edition, Including All Revisions.
- K UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.
- L UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.
- M UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A See Division 01 - 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.
 - 2. Manufacturer's catalog sheets for fixtures, fittings, accessories, and supplies.
- C Shop Drawings: Include dimensions and performance data.
- D Test Reports: Plumbing fixture operational tests.
- E Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- F Executed warranty.
- G Specimen warranty.
- H Project Record Documents: Record actual locations of components.
- I Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- J Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Division 01 - Product Requirements for additional provisions.
 - 2. Extra Pump Seals: One of each type and size.

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1.5 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing type of products specified in this section, with minimum three years of documented experience.
- B Certifications: Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc, as suitable for purpose specified and indicated.
- C Identification: Provide pumps with manufacturer's name, model number, and rated capacity identified by permanently attached label.
- D Performance: Ensure pumps 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.

1.6 DELIVERY, STORAGE, AND HANDLING

- A See Division 01 - Construction Waste Management and Disposal for packaging waste requirements.
- B Provide temporary inlet and outlet caps. Maintain caps in place until installation.
- C Protect bearings and couplings against damage.
- D Comply with pump manufacturer's written instructions for handling.

1.7 WARRANTY

- A See Division 01 - Closeout Submittals for additional warranty requirements.
- B Manufacturer Warranty: Provide 1-year manufacturer warranty for pumps except circulator type. Complete forms in Owner's name and register with manufacturer.
- C Manufacturer Warranty: Provide 5-year manufacturer warranty for circulators. Complete forms in Owner's name and register with manufacturer.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B UL Compliance: UL 778 for motor-operated water pumps.
- C Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

2.2 CIRCULATORS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Armstrong Fluid Technology
 - 2. Bell & Gossett, a Brand of Xylem, Inc
 - 3. Grundfos Pumps Corporation
 - 4. Taco, Inc
- B Refer to Schedule on drawings.
- C Impeller: MAKE A SELECTION, fully enclosed, keyed directly to solid alloy steel with bronze sleeve shaft.
- D Casing: MAKE A SELECTION with bronze MAKE A SELECTION cast impeller, and stainless steel rotor assembly.
- E Shaft: Alloy steel with integral thrust collar and two oil-lubricated bronze sleeve bearings.
- F Bearings: MAKE SELECTIONS ball type.
- G Mechanical Seal: MAKE SELECTIONS.
- H Pipe-End Connection: MAKE A SELECTION connection.
- I Maximum Working Pressure: MAKE A SELECTION.
- J Motor: 1750 MAKE A SELECTION rpm, MAKE A SELECTION.
- K Service Temperature Range: _____ degrees F (_____ degrees C).
- L Controls: Provide MAKE SELECTION(S).

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M BMS or Other Integrated Automation Link: Provide auxiliary contacts for fault and run status.

N Accessories: Include MAKE A SELECTION.

2.3 INLINE PUMPS

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Armstrong Fluid Technology
2. Bell & Gossett, a Brand of Xylem, Inc
3. Grundfos Pumps Corporation
4. Taco, Inc

B Refer to Schedule on drawings.

C Description: MAKE A SELECTION coupled, end-suction pump with integral controls for heads up to 175 psi (1206 kPa)

D Type: MAKE A SELECTION with MAKE A SELECTION pipe-end connections.

E Casing: MAKE A SELECTION with renewable bronze casing wearing rings and seal flush connection.

F Impeller: MAKE A SELECTION, fully enclosed, keyed directly to solid alloy steel with bronze sleeve shaft.

G Bearings: MAKE SELECTIONS ball type.

H Mechanical Seal: MAKE SELECTIONS.

I Electrical:

1. Motor: MAKE A SELECTION rpm, MAKE A SELECTION; see Section 220513.
2. Motor Controller: MAKE A SELECTION.
3. Motor Protection: Include MAKE SELECTIONS.
4. Pilot Indicators: Provide fault or trip and MAKE SELECTIONS.
5. Wiring Connections: See Section 260583.
6. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

J Integral Controls:

1. Variable Frequency Drive (VFD): Factory-fitted and tested with dedicated terminal box for power, instrumentation, and related control wiring.

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2. DDC Controller: VFD-integrated or external controller module with visual-tactile interface and minimum of MAKE SELECTIONS.
3. BMS, SCADA, or Other Integrated Automation Link: ASHRAE Std 135 BACnet MS/TP.

K Accessories: Include MAKE SELECTIONS.

2.4 PRESSURE BOOSTER SYSTEMS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Armstrong Fluid Technology
 2. Bell & Gossett, a Brand of Xylem, Inc
 3. Grundfos Pumps Corporation
 4. TIGERFLOW Systems, Inc.
 5. Quantumflo
- B Refer to Schedule on drawings.
- C Description: Self-contained factory assembled pump skid with isolation valves, strainers, gauges, pipe and flanged fittings, system drain valve(s), component identification, signage, electrical raceway, equipment tags, instruments, and controls fitted on fabricated structural steel frame skid base; tested, adjusted, and shipped as integral unit.
- D Pumps, End Suction, Close Coupled:
1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
 2. Casing: Radially split; stainless steel.
 3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 4. Shaft and Shaft Sleeve: Stainless steel shaft, with copper-alloy shaft sleeve and deflector.
 5. Seal: Mechanical.
 6. Orientation: Mounted vertically
- E Pumps, End Suction, Frame Mounted, Separately Coupled:
1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, frame-mounted, separately coupled, single-stage, overhung-impeller, centrifugal pump. Include back-pullout design.
 2. Casing: Radially split; stainless steel.
 3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 4. Shaft and Shaft Sleeve: Stainless steel shaft, with copper-alloy shaft sleeve and deflector.
 5. Seal: Mechanical.
 6. Bearing: Grease-lubricated ball type.
 7. Coupling: Flexible, with metal guard.
- F Pumps, In Line, Single Stage:

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1. Type: In line, single stage as defined in HI 1.1-1.2 and HI 1.3 for in-line, single-stage, close-coupled, overhung-impeller, centrifugal pump.
 2. Casing: Radially split; stainless steel.
 3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 4. Shaft and Shaft Sleeve: Stainless steel shaft, with copper-alloy shaft sleeve and deflector.
 5. Seal: Mechanical.
 6. Bearing: Grease-lubricated ball type.
- G Pumps, Vertical, Multistage:
1. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
 2. Casing: Cast-iron or steel base and stainless-steel chamber.
 3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 4. Shaft: Stainless steel.
 5. Seal: Mechanical.
 6. Bearing: Water-lubricated sleeve type.
- H Pumps, Vertical, Can:
1. Type: Vertical, can, as defined in HI 2.1-2.2 and HI 2.3 for in-line, barrel or can, lineshaft, vertical pump.
 2. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 3. Bowls: Epoxy-coated cast iron
 4. Shaft: Stainless steel.
 5. Seals: Mechanical and stuffing-box types.
 6. Bearings: Water-lubricated bushing type.
- I Motor: Single speed, with MAKE SELECTIONS, ball-bearings, and directly mounted to pump casing. Select motor that will not overload through full range of pump performance curve.
- J Piping: Copper tube and copper fittings.
- K Valves:
1. Shutoff Valves 2 inch (50 mm) 2 inch (50 mm) and Smaller: MAKE SELECTIONS, in pump suction and discharge piping.
 2. Shutoff Valves 2-1/2 inch (65 mm) and Larger: MAKE SELECTIONS, in pump suction and discharge piping.
 3. Check Valve 2 inch (50 mm) and Smaller: MAKE SELECTIONS type in pump discharge piping.
 4. Check Valve 2-1/2 inch (65 mm) and Larger: Silent type in pump discharge piping.
 5. Thermal-Relief Valve: Temperature-and-pressure relief type in pump discharge piping.
- L Dielectric Fittings: With insulating material to isolate joined dissimilar metals.

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- M Hydropneumatic Tank: PrechargedMAKE A SELECTION diaphragm or bladder tank made of materials complying with NSF 61 and NSF 372.
- N Maximum Discharge Pressure: MAKE A SELECTION.
- O Skid Capacity Load Distribution:
1. Duplex; lead and lag at _____ percent
 2. Duplex; lead at _____ percent and lag at _____ percent
 3. Triplex; 2 leads at _____ percent and lag at _____ percent
 4. Quad; 3 leads at _____ percent and lag at _____ percent
 5. _____
- P Pump Assembly: End-suction type, stainless steel casing, stainless steel MAKE A SELECTION impeller and bearings.
- Q Pump Motor: Inverter duty, VFD-controlled 1750 rpm, open drip-proof (ODP) MAKE A SELECTION type.
- R Pipe-End Connections: MAKE A SELECTION flange for sizes 4 inches (100 mm, DN) and larger otherwise threaded.
- S Pipe and Fittings Material: Stainless steel, Schedule 40.
- T Low-Pressure Control: Stop pump operation if incoming water pressure drops to atmospheric.
- U Isolation and Control Valves:
1. Butterfly valves at pump suction and discharge sides for pipe sizes above 4 inches (100 mm, DN), ball valves are acceptable for smaller pipe sizes.
- V Component Identification: ASME A13.1 for pipes and equipment and NFPA 70 for electrical.
- W Accessories: Include MAKE SELECTIONS.
- X Instrumentation and Controls:
1. Provide skid-mount instruments and control devices where required with proper raceway, cables, and wires into control panel with panel-door interlocked main disconnect switch.
 2. Instrument, Device, and Control-Enclosure Rating: NEMA EN 10250, MAKE A SELECTION.
 3. Controller Type: Panel-coordinated programmable logic controller (PLC) with fuse protected controls transformer and power supplies.
 4. Variable Speed Pumps
 - a. VFC Specified in Other Section: Comply with Section 220934 - NOT OEC EDITED - Variable-Frequency Motor Controllers for Plumbing.

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5. Pump Operation: pressure- sensing method.
6. Instrumentation: Suction and discharge pressure gauges.
7. Operating Interface per Pump:
 - a. Components: HOA selector switch, suction, and discharge side pressure gauges, resettable run-time meter per pump.
 - b. Indicators: Provide illuminated indicators of incandescent or LED-based pilot light type per pump.
 - c. Graphic Panel: Color touchscreen display, use graphics instead of listed components, and indicators except for pump override switches with respective indicators.
8. Minimum Control Components:
 - a. Magnetic starter or variable frequency drive for motor control with overcurrent protection (in each phase), overvoltage protection and current sensor per pump.
 - b. Thermal Bleed Circuit with Solenoid Valve: Prevent overheating during low demand.
 - c. Pump Alternating: Have pumps set for lead/lag operation. Alternate pumps based on run time or manually selected order. Use alternating relay for noncontroller system.
 - d. Low- and High-Limit pressure cutout and temperature cut out switches.
 - e. Pressure Control Signal: Include pressure-indicating transmitter for remote mounting.
 - f. Time Delay Function or Relay: Prevent lag pumps short cycling on fluctuating demands.
 - g. Time Clock Function or Relay for Automatic Day-Night Changeover:
 - 1) Day Cycle: System to operate continuously with pressure to fixtures maintained by pressure-reducing valves.
 - 2) Night Cycle: Pump to operate intermittently on pressure switch located near pressure tank operating pump for predetermined adjustable time period.
9. BAS, BMS, SCADA, or Other Integrated Automation Link:
 - a. BACnet MS/TP in accordance with ASHRAE Std 135.
10. Alarm and Warning Indicator: Panel-mounted audio-visual station with stack-fitted red and amber colored lamps, auxiliary contacts, and 100 dB, strobe or horn.

2.5 MOTORS

- A Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 - Common Motor Requirements for Plumbing Equipment.
 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

2.6 CONTROLS

- A Pressure Switches: Electric, adjustable for control of pump.
 1. Type: Water-immersion pressure sensor, for installation in piping.
 2. Enclosure: NEMA 250, Type 4X

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3. Operation of Pump: On or off.
 4. Transformer: Provide if required.
 5. Power Requirement: 208/3.
- B Thermostats: Electric; adjustable for control of hot-water circulation pump.
1. Type: Water-immersion temperature sensor, for installation in piping.
 2. Range: _____ deg F (_____ deg C) to _____ deg F (_____ deg C)
 3. Enclosure: NEMA 250, Type 4X.
 4. Operation of Pump: On or off.
 5. Transformer: Provide if required.
 6. Power Requirement: 120 V AC
 7. Settings: Start pump at 105 deg F (41 deg C) and stop pump at 120 deg F (49 deg C).
- C Timers: Electric, for control of hot-water circulation pump.
1. Programmable, 7 day clock with manual override on-off switch.
 2. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
 3. Operation of Pump: On or off.
 4. Transformer: Provide if required.
 5. Power Requirement: 120 V AC.
- D Time-Delay Relays: Electric, for control of hot-water circulation pump between water heater and connected hot-water storage tank.
1. Type: Adjustable time-delay relay.
 2. Range: Up to five minutes.
 3. Setting: Five minutes.
 4. Enclosure: NEMA 250, Type 4X.
 5. Operation of Pump: On or off.
 6. Transformer: Provide if required.
 7. Power Requirement: 120 V AC.
 8. Programmable Sequence of Operation: Limit pump operation to periods of burner operation, plus maximum five minutes after the burner stops.

2.7 SOURCE QUALITY CONTROL

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application..
- B ASME Compliance: Comply with ASME B31.9 for piping.
- C UL Compliance for Packaged Pumping Systems:
1. UL 508
 2. UL 508A
 3. UL 778
 4. UL 1995

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- D Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine roughing-in for domestic-water-piping system to verify actual locations of piping connections before pump installation.
- B Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

3.2 INSTALLATION

- A Comply with ANSI/HI 1.4
- B Install products with related fittings, and accessories according to manufacturer instructions.
- C Mount pumps in orientation complying with manufacturer's written instructions.
- D Support connected domestic-water piping so weight of piping is not supported by booster pumps.
- E Potable and Drinking Water Service: Provide NSF 61 certified; comply with ICC (IPC).
- F 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.
- G Ensure that small pressure gauges are installed on both upstream and downstream ends.
- H Inline Pump Mounting
 - 1. Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using vibration isolation type and deflection as specified in 220548 - NOT OEC EDITED - Vibration and Seismic Controls for Plumbing Piping and Equipment. Comply with requirements for concrete base specified in Division 03 - Cast-in-Place Concrete.

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2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch (450 mm), centers around the full perimeter of concrete base.
 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 6. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.
 - a. Comply with requirements for vibration isolation devices specified Section 220548 - NOT OEC EDITED - Vibration and Seismic Controls for Plumbing Piping and Equipment. Fabricate brackets or supports as required.
 - b. Comply with requirements for hangers and supports specified in Section 220529 - Hangers and Supports for Plumbing Piping and Equipment - PENDING APPROVAL.
- I **Booster-Pump Mounting:**
1. Install booster pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in SecDivision 03 - Cast-in-Place Concrete.
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 - NOT OEC EDITED - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- J **Base-Mount Pumps and Pressure Booster Pump Skids:**
1. Provide air cock and drain connection. Align and verify alignment of base prior to start-up.
 2. Provide line-sized isolating valve with strainer on suction end and line-sized, soft-seated check valve with isolating valve and balancing valve on discharge end.
 3. 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. Provide supports under elbows on pump suction and discharge line sizes 4 inches (100 mm) and over.
- K **Hot Water Service:** Ensure that small pressure-temperature gauges are installed on both upstream and downstream ends.
- L **MAKE A SELECTION Pump Controls:** Factory provided, tested for use.
- M **Cycle Duty Controlled Pumps:** MAKE A SELECTION.
- N **ECM, VSD, or VFD Controlled Motors:** Configure unit to operate within manufacturer-listed pump curve points unless factory set to do so. Then adjust to operate MAKE A SELECTION.
- O **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.**

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- P Coordinate BAS, BMS, or Integrated Automation linking between unit controller and remote software app or terminal; see Section 253500.
- Q Install pressure switches in water-supply piping.
- R Install thermostats in hot-water return piping.
- S Install timers on wall in _____.
- T Install time-delay relays in piping between water heaters and hot-water storage tanks.

3.3 PIPE CONNECTIONS

- A Comply with requirements for piping specified in Section 221005 - Plumbing Piping. Drawings indicate general arrangement of piping, fittings, and specialties.
- B Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.
- C Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - c. Vertically mounted, in-line, close-coupled centrifugal pumps.
 - d. Comply with requirements for flexible connectors specified in Section 221005 - Plumbing Piping.
- D Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221006 - Plumbing Piping Specialties. Comply with requirements for valves specified in Section 220523 - General-Duty Valves for Plumbing Piping.
 - 1. Install pressure gauge and snubber at suction of each pump and pressure gauge and snubber at discharge of each pump. Install at integral pressure-gauge tapings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 220500 - Common Work Results for Plumbing.
- E Booster-Pump Piping Connections: Connect domestic-water piping to booster pumps. Install suction and discharge pipe as indicated on drawings.

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1. Install shutoff valves on piping connections to booster-pump suction and discharge piping. Install ball, butterfly, or gate valves same size as suction and discharge piping. Comply with requirements for general-duty valves specified in Section 220523 - General-Duty Valves for Plumbing Piping.
2. Install union, flanged, or grooved-joint connections on suction and discharge piping at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Section 221005 - Plumbing Piping.
3. Install valved bypass, same size as piping, at connections to booster-pump suction and discharge piping. Comply with requirements for domestic-water piping specified in Section 221005 - Plumbing Piping.
4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge piping. Comply with requirements for flexible connectors specified in Section 221005 - Plumbing Piping.
5. Where installing piping adjacent to booster pumps, allow space for service and maintenance.

3.4 ELECTRICAL CONNECTIONS

- A Connect wiring according to Division 26.
- B Ground equipment according to Division 26.
- C Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70.

3.5 CONTROL CONNECTIONS

- A Install control and electrical power wiring to field-mounted control devices.
- B Connect control wiring according to Division 26.
- C Connect control wiring between temperature controllers and devices.

3.6 IDENTIFICATION

- A Identify system components. Comply with requirements for identification specified in Section 220553 - Identification for Plumbing Piping and Equipment.
- B Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

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3.7 FIELD QUALITY CONTROL

- A See Division 01 - 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.
- C Testing Agency:
 - 1. Engage a qualified testing agency to perform tests and inspections.
- D Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- E Perform tests and inspections .
- F Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- G Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.
- H Prepare test and inspection reports.

3.8 STARTUP SERVICE

- A Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set pressure switches for automatic starting and stopping operation of pumps.
 - 5. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

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7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.9 ADJUSTING

- A Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B Adjust initial temperature set points.
- C Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D Adjust booster pumps to function smoothly, and lubricate as recommended by manufacturer.
- E Adjust pressure set points.
- F Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

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

3.11 CLEANING

- A Thoroughly clean plumbing fixtures and equipment.
- B See Section Division 07 - Construction Waste Management and Disposal for additional requirements.

3.12 PROTECTION

- A Protect installed products from damage from subsequent construction operations.
- B Repair or replace products damaged before Date of Substantial Completion.

END OF SECTION 221123

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SECTION 221429
SUMP PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Pedestal sump pumps.
- B Submersible sump pumps.

1.2 REFERENCE STANDARDS

- A ASME A17.1 - Safety Code for Elevators and Escalators Includes Requirements for Elevators, Escalators, Dumbwaiters, Moving Walks, Material Lifts, and Dumbwaiters with Automatic Transfer Devices; 2022.
- B ICC (IPC) - International Plumbing Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D UL (DIR) - Online Certifications Directory; Current Edition.
- E UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.

1.3 SUBMITTALS

- A See Section 013000 - Administrative Requirements for submittal procedures.
- B Product Data Submittals: For each product.
 - 1. Construction details, material descriptions, dimensions of individual components and profiles.
 - 2. Rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting/attachment details.

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- 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- E Executed warranty.

1.4 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section with three years minimum of documented experience.
- B Certifications: UL (DIR) listed, classified, and suitable for the purpose specified and indicated.
- C Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

1.5 DELIVERY, STORAGE, AND HANDLING

- A See Division 01 - Construction Waste Management and Disposal for packaging waste requirements.
- B Provide temporary inlet and outlet caps. Maintain caps in place until installation.
- C Retain shipping flange protective covers and protective coatings during storage.
- D Protect bearings and couplings against damage.
- E Comply with manufacturer's written instructions for handling.

1.6 WARRANTY

- A See Division 01 - Closeout Submittals for additional warranty requirements.
- B Manufacturer Warranty: Provide 1-year manufacturer warranty from date of Substantial Completion for pumps and related components. Complete forms in Owner's name and register with manufacturer.

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- C Submit warranty with related forms completed in Owner's name and registered with manufacturer.
- D Failures include, but are not limited to, the following:
 - 1. Faulty operation
 - 2. Deterioration of metals, metal finishes, and other materials beyond normal weathering or use.

PART 2 PRODUCTS

2.1 SOURCE LIMITATIONS

- A Obtain each type of sump pump from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- B UL Compliance: Comply with UL 778 for motor-operated water pumps.

2.3 PEDESTAL SUMP PUMPS

- A Manufacturers:
 - 1. Goulds Water Technology; a Xylem brand
 - 2. Pentair Aurora; Pentair Pump Group
 - 3. Zoeller Pump Company
 - 4. Stancor.
- B Refer to Schedule on drawings.
- C Description: Factory-assembled and -tested, automatic-operation, freestanding, sump-pump unit.
- D Pump Type: Wet-pit-volute, single-stage, separately coupled, overhung-impeller centrifugal sump pump, configured as a pedestal pump. Sump pump to be as defined in HI 14.1-14.2 and HI 14.3.
- E Materials: Corrosion-resistant material pump column housing and base with noncorrosive stainless steel shaft and impeller. Provide with strainer inlet; design that permits flow into impeller; and vertical discharge for piping connection.

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- F Impeller: Aluminum, brass, or plastic.
- G Motor: Top mount, enclosed, thermal-overload protected, continuous duty, permanent split capacitor with oil-resistant, three-prong connector, 10 foot (3 m) power cord. With built-in overload protection and mounted vertically on sump-pump column.
- H Controls: Chemically resistant, shaft-supported, steel-rod mount, adjustable vertical float switch.
- I Solids Handling Capacity: Pass lint and other small solids up to 3/16 inch (4.8 mm) in size.
- J Discharge Port Size: 1-1/4 inch (32 mm, DN), NPT, female.
- K Maximum Water-Based Effluent Temperature: 140 degrees F (60 degrees C).
- L Accessories: Provide full flow swing-type discharge check valve, high-level audio/visual alarm system, and 12 VDC backup battery sized for 2 hours of backup operation.
- M Control: Float switch.

2.4 SUBMERSIBLE SUMP PUMPS

- A Manufacturers:
 - 1. EBARA Pumps Americas Corp.
 - 2. Grundfos Pumps Corporation
 - 3. Liberty Pumps
 - 4. PROFLO
 - 5. Weil Pump; a Wilo Company]
 - 6. Zoeller Company
 - 7. Stancor.
- B Refer to Schedule on drawings.
- C Description: Factory-assembled and -tested sump-pump unit.
- D Description: Factory-assembled and -tested sump-pump unit. ASME A17.1 compliant.
- E Number of Pumps: One
- F Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 14.1-14.2 and HI 14.3.

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- G General: Cast iron housing, with strainer inlet; legs that elevate pump to permit flow into impeller; and vertical discharge for piping connection. and base ball bearings, and mechanical seal.
- H Impeller: Statically and dynamically balanced, Cast iron; open nonclog, -MAKE A SELECTION- shaft. Designed for clear wastewater handling, and keyed and secured to shaft.
- I Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
- J Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
- K Motor: Base mount, Hermetically sealed, enclosed, thermal-overload protected, continuous duty, permanent split capacitor with oil-resistant, three-prong connector, 10 foot (3 m) power cord.
- L Solids Handling Capacity: Pass lint and other small solids up to 1/2 inch (15 mm) in size.
- M Discharge Pipe Size: 2 inch (50 mm, DN), NPT, female.
- N Maximum Water-Based Effluent Temperature: 120 degrees F (48,9 degrees C).
- O Accessories: Provide full flow swing-type discharge check valve, high-level audio/visual alarm system, and 12 VDC backup battery sized for 2 hours of backup operation.
- P Controls:
1. Cycle pump Off/On between _____ inch (_____ cm) heights from bottom of pump.
 2. Controls, Rod-and-Float Type:
 - a. Enclosure: NEMA 250, Type 4X.
 - b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
 - c. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inch (1500 mm).
 - d. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.
 3. Controls, Float- and Pressure-Switch Type:
 - a. Enclosure: NEMA 250, Type 4X; wall mounted.
 - b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - c. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with Mechanical-float switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.
 4. Oil-Sensing Sump Pumps Controls
 - a. Industrial-grade switch(es) with internal _____ A relay and Type 304 stainless steel sensor probes.

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- b. Liquid/oil sensor that differentiates and indicates the presence of oil and/or water under high-water conditions.
- c. Alarm Panel:
 - 1) High-oil-level alarm.
 - 2) High-water-level alarm.
 - 3) Audible and visual alarms for each alarm condition.
 - 4) Dry contacts for remote monitoring of oil, water, and high liquid conditions.
- d. Control Panel:
 - 1) Simplex
 - 2) Enclosure: NEMA 250, Type 4X.
 - 3) HOA switch(es).
 - 4) Green pump run light; power on light.
 - 5) Pump circuit breaker(s).
- 5. Control-Interface Features:
 - a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.

2.5 MOTORS

- A Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220500 - Common Work Results for Plumbing.
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B Motors for submersible pumps are to be hermetically sealed.

PART 3 EXECUTION

3.1 EARTHWORK

- A Excavation and filling are specified in Division 31 - Earth Moving

3.2 EXAMINATION

- A Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump-pump installation.

3.3 INSTALLATION

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- A Pump Installation Standards: Comply with HI 14.4 for installation of sump pumps.
- B Install products with related fittings and accessories according to manufacturer instructions.
- C Observe and provide incidentals required to complete installation in compliance with ICC (IPC).
- D Equipment Mounting:
 - 1. Comply with requirements for vibration isolation control devices specified in Section 220548 - NOT OEC EDITED - Vibration and Seismic Controls for Plumbing Piping and Equipment.
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 - NOT OEC EDITED - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- E Wiring Method: Comply with requirements in Division 26 - Low-Voltage Electrical Power Conductors and Cables.
- F Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.4 PIPING CONNECTIONS

- A Comply with requirements for piping specified in Section 221005 - Plumbing Piping. Drawings indicate general arrangement of piping, fittings, and specialties.
- B Where installing piping adjacent to equipment, allow space for service and maintenance.

3.5 STARTUP SERVICE

- A Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.

3.6 ADJUSTING

- A Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
- B Adjust control set points.

3.7 FIELD QUALITY CONTROL

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- A See Division 01 - Quality Requirements for additional requirements.
- 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, inspect, and adjust components, assemblies, and equipment installations, including connections.
- D Tests and inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Pumps and controls will be considered defective if they do not pass tests and inspections.
- E Prepare test and inspection reports.

3.8 DEMONSTRATION

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

3.9 CLEANING

- A See Division 01 - Construction Waste Management and Disposal for additional requirements.

3.10 PROTECTION

- A Protect installed products from damage from subsequent construction operations.

END OF SECTION 221429

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SECTION 223000
PLUMBING EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Commercial gas-fired water heaters.
- B Domestic hot water storage tanks.
- C Diaphragm-type compression tanks.
- D Reverse osmosis equipment.
- E Domestic, storm, and sanitary-sewage pumps.

1.2 REFERENCE STANDARDS

- A 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).
- B 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).
- C ANSI Z21.15 - Manually operated gas valves for appliances, appliance connector valves and hose end valves; R2019.
- D ANSI Z21.20 - Automatic Gas Ignition Systems and Components; R2016.
- E ANSI Z21.21 - Automatic Valves; 2023.
- F ANSI Z21.22 - American National Standard for Relief Valves for Hot Water Supply Systems; 2015 (Reaffirmed 2020).
- G 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.
- H ASME B1.20.1 - Pipe Threads, General Purpose, Inch; 2013 (Reaffirmed 2018).

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- I ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard; 2020.
- J ASME B16.24 - Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500; 2021.
- K ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2023.
- L ASSE 1010 - Performance Requirements for Water Hammer Arresters; 2021.
- M NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- N NFPA 54 - National Fuel Gas Code; 2024.
- O NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- P NSF 61 - Drinking Water System Components - Health Effects; 2024.
- Q NSF 372 - Drinking Water System Components - Lead Content; 2024.
- R PDI-WH 201 - Water Hammer Arresters; 2017.
- S UL 795 - Commercial-Industrial Gas Heating Equipment; Current Edition, Including All Revisions.

1.3 ADMINISTRATIVE REQUIREMENTS

- A Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by affected installers.
- B Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.4 SUBMITTALS

- A See Division 01 - Administrative Requirements for submittals procedures.
- B Product Data:

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1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
 2. Provide electrical characteristics and connection requirements.
 3. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 4. Rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C Shop Drawings:
1. Indicate heat exchanger dimensions, size of tappings, and performance data.
 2. Indicate dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tappings, and drains.
 3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 4. Wiring Diagrams: For power, signal, and control wiring.
- D Informational Submittals
1. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale, on which the items described in this Section are shown and coordinated with all building trades.
 2. Certificates of Shop Inspections and Data Reports: For products required to have ASME label, signed by product manufacturer.
 3. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
 4. Product Certificates: For each type of domestic-water heater.
 5. Welding certificates.
 6. Source quality-control reports.
 7. Field quality-control reports.
 8. Sample Warranty: For special warranty.
- E Project Record Documents: Record actual locations of components.
- F Design Submittals:
1. Product Data: For energy efficiency.
- G Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- H Warranty Documentation: Submit manufacturer warranty and ensure that 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 Division 01 - Product Requirements for additional provisions.

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1.5 QUALITY ASSURANCE

- A Welding Qualifications: Qualify processes and operators in accordance with ASME Boiler and Pressure Vessel Code.
- B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- D Certifications:
 - 1. Water Heaters: NSF approved.
 - 2. Gas Water Heaters: ANSI Z21.10.1 and ANSI Z21.10.3.
 - 3. Water Tanks: ASME labeled to ASME BPVC-VIII-1.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 WARRANTY

- A See Section Division 01 - Closeout Submittals for additional warranty requirements.
- B Manufacturer Warranty: Provide 5-year manufacturer warranty for domestic water heaters, water storage tanks, and packaged water heating systems. Complete forms in Owner's name and register with manufacturer.
- C Special Warranty: Manufacturer agrees to repair or replace components of domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - 2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: -MAKE A SELECTION- years.
 - 2) Controls and Other Components: -MAKE A SELECTION- year(s).
 - b. Expansion Tanks: 5 years.

1.8 FIELD CONDITIONS

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- A Interruption of Existing Chemical-Waste Service: Do not interrupt chemical-waste service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary chemical-waste service in accordance with requirements indicated:
1. Notify Owner no fewer than two days in advance of proposed interruption of chemical-waste service.
 2. Do not proceed with interruption of chemical-waste service without Owner's written permission.

1.9 COORDINATION

- A Coordinate size and location of concrete bases with actual equipment provided.

PART 2 PRODUCTS

2.1 SOURCE LIMITATIONS

- A Obtain each product type from single manufacturer.

2.2 WATER HEATERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. A.O. Smith Water Products Co
 2. AERCO
 3. Bradford White Corporation
 4. Intellihot
 5. Lochinvar, LLC
 6. Raypak
- B Performance Requirements
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
 2. ASHRAE/IES Compliance: Applicable requirements in ASHRAE Std 90.1 I-P.
 3. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - a. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - b. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

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4. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

C Commercial Gas-Fired Water Heaters:

1. Type: Automatic, natural gas-fired, vertical storage.
2. Minimum Efficiency Required: ASHRAE Std 90.1 I-P.
3. Refer to Schedule on drawings.
4. Standard: ANSI Z21.10.3.
5. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.
6. Storage-Tank Construction: -MAKE A SELECTION-ASME-code steel with 150 psig (1035 kPa) working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) 2 inch (50 mm) and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - 2) 2-1/2 inch (65 mm) and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
7. Factory-Installed, Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal with hose-end connection.
 - d. Insulation: Comply with ASHRAE Std 90.1 I-P. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and applicable fuel.
 - g. Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.
 - h. Temperature Control: Adjustable thermostat.
 - i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.20. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
8. Direct-Vent System: Through--MAKE A SELECTION-, vent assembly with domestic-water heater manufacturers' outside intake/exhaust screen.
9. Accessories:
 - a. Temperature and Pressure Relief Valve: ASME labeled.

D Source Quality Control

1. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.

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2. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

2.3 DOMESTIC HOT WATER STORAGE TANKS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Aerco
 2. A.O. Smith Water Products Co
 3. Bradford White Corporation
 4. Lochinvar
 5. PVI
 6. Rheem
- B Refer to Schedule on drawings.
- C Storage Capacity: -MAKE A SELECTION-, minimum holding capacity.
- D Tank: Welded steel, ASME labeled for working pressure of -MAKE A SELECTION-, steel support saddles, tappings for accessories, threaded connections of stainless steel, access manhole.
- E Insulation: 2 inch (51 mm) thick, non-cfc foam on respective top and tank sides.
- F Lining: Corrosion-resistant high silica epoxy continued into screwed connections.
- G Openings and Connections:
1. Threaded -MAKE A SELECTION- top hot water outlet and -MAKE A SELECTION- bottom cold water inlet, -MAKE A SELECTION-.
 2. -MAKE A SELECTION- openings for aquastat, drain, PT release valve, and pump circulation.
 3. -MAKE A SELECTION- hand-hole cleanout access opening with cover.
- H Accessories: Provide aquastat, backflow preventer, cold water isolation valve, drain valve, hot water isolation valve, pressure-temperature (PT) relief valve ASME rated for maximum working pressure, and thermometer with range of 40 to 200 degrees F (4 to 93 degrees C).

2.4 DIAPHRAGM-TYPE COMPRESSION TANKS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. A. O. Smith Corporation

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2. Amtrol Inc
3. Bell & Gossett, a brand of Xylem, Inc
4. State Industries
5. Taco, Inc
6. Watts

B Refer to Schedule on drawings.

C Construction: Welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; supplied with National Board Form U-1, rated for working pressure of 125 psig (860 kPa), with flexible EPDM diaphragm sealed into tank, and steel legs or saddles. Include air precharge to minimum system-operating pressure at tank.

1. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
2. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
3. Air-Charging Valve: Factory installed.

D Accessories: Shutoff valve on inlet piping, Pressure gauge and air-charging fitting, tank drain.

2.5 DOMESTIC-WATER HEATER ACCESSORIES

A Drain Pans: Corrosion-resistant metal with raised edge. Include drain outlet not less than 3/4 inch (20 mm) with ASME B1.20.1 pipe threads.

B Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE Std 90.1 I-P.

C Heat-Trap Fittings: ASHRAE Std 90.1 I-P.

D Manifold Kits (when applicable): Domestic-water-heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and balancing valves to provide balanced flow through each domestic-water heater.

E Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 220523 - General-Duty Valves for Plumbing Piping.

1. Comply with requirements for balancing valves specified in Section 221006 - Plumbing Piping Specialties.

F Gas Shutoff Valves: ANSI Z21.15 appliance type. Include pressure rating as required to match gas supply.

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- G Automatic Gas Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.
- H Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
 - 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22.
 - 2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.
- I Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.
 - 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22.
 - 2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.
- J Vacuum Relief Valves: ANSI Z21.22.
- K Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.
- L Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 18 inch (457 mm) above the floor.
- M Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.6 REVERSE OSMOSIS EQUIPMENT

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. 3M
 - 2. Culligan International Company
 - 3. Ecodyne Limited
 - 4. EVOQUA Water Technologies
 - 5. Marlo Incorporated
 - 6. Pentair, Inc.
 - 7. WATTS; A Watts Water Technologies Company
 - 8. Water Control Corporation.
- B Refer to Schedule on drawings.
- C Pressurized Membrane System: High-pressure pump forces water through the membrane(s) to remove 99 percent of organic solids, bacteria, contaminants, and particles and 97 percent of dissolved solids.

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- D Pre-filtration: Polypropylene depth filters, capable of removing 90 percent of particles greater than 5 micron.
 - 1. Housing:
 - a. Type 304 stainless steel.
 - b. Include vent and drain plugs with EPDM o-rings.
 - c. Include Type 304 pressure gauge at the inlet and outlet.
- E Membrane modules with thin-film composite type membranes and membrane vessels to allow a maximum flux for the following:
 - 1. First Stage: _____ gallons per square foot per day (_____ liters per square meter per day) of membrane surface area at 17 percent recovery.
 - 2. Second Stage: _____ gallons per square foot per day (_____ liters per square meter per day) per day of membrane surface area at 35 percent recovery.
- F Panel-Mounted Controls and Instrumentation on a Common Frame:
 - 1. Material: Epoxy-coated aluminum.
 - 2. Features:
 - a. Flow meters
 - b. Type 304 stainless steel pressure gauges for pump discharge and regulated pump pressure.
 - c. Control valves.
 - d. Pump starter with indicated light.
 - e. Feedwater pressure switch with time delay for low-pressure shutdown.
 - f. Time controller for automatic fast flush.
 - g. Monitor/controller with selector switch for feed to monitor conductivity.
 - h. Trouble alarm with ability to connect to the building management system.
- G Piping, Equipment, and Controls: Factory mounted on steel frame.

2.7 DOMESTIC, STORM, AND SANITARY-SEWAGE PUMPS

- A Domestic Water Pumps: See Section 221123.
- B Sump Pumps: See Section 221429.
- C Sanitary Sewerage Pumps: See Section 221429.

PART 3 EXECUTION

3.1 INSTALLATION OF DOMESTIC-WATER HEATER

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- A Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section Division 03 Section - Cast-in-Place Concrete.
1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 2. Maintain manufacturer's recommended clearances.
 3. Arrange units so controls and devices that require servicing are accessible.
 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch (450 mm) centers around the full perimeter of concrete base.
 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 8. Anchor domestic-water heaters to substrate.
 9. Install water heaters in minimum 2" deep galvanized steel drain pan. Route drain from drain pan to terminate where indicated on drawings.
- B Install domestic-water heaters level and plumb, in accordance with layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 - General-Duty Valves for Plumbing Piping.
- C Install gas-fired, domestic-water heaters in accordance with NFPA 54.
1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
 2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
 3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
 4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in 221005 - Plumbing Piping.
 5. Provide high efficiency, condensing gas water heaters with manufacturers condensate neutralizing kit. extend drain from neutralizing kit to terminate where indicated on drawings.
 6. Refer to Division 23 specifications and drawings for information pertaining to gas water heater venting.
 7. Gas water heaters shall be elevated not less than 18 inches above the floor, or as required per the local fuel gas code, when installed in hazardous areas such as garages.
- D Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

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- E Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend domestic-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- F Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221005 - Plumbing Piping.
- G Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220500 - Common Work Results for Plumbing.
- H Assemble and install inlet and outlet piping manifold kits for multiple domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each domestic-water heater outlet. Comply with requirements for valves specified in Section 220523 - General-Duty Valves for Plumbing Piping and comply with requirements for thermometers specified in Section 220500 - Common Work Results for Plumbing.
- I Install pressure-reducing valve with integral bypass relief valve in electric, domestic-water booster-heater inlet piping and water hammer arrester in booster-heater outlet piping. Set pressure-reducing valve for outlet pressure of 25 psig (172 kPa). Comply with requirements for pressure-reducing valves and water hammer arresters specified in Section 221006 - Plumbing Piping Specialties.
- J Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.
- K Fill domestic-water heaters with water.
- L Charge domestic-water expansion tanks with air to required system pressure.
- M Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight.

3.2 PIPING CONNECTIONS - WATER HEATERS

- A Comply with requirements for domestic-water piping specified in Section 221005 - Plumbing Piping.

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- B Comply with requirements for fuel-oil piping specified in Section 221005 - Plumbing Piping.
- C Comply with requirements for gas piping specified in 221005 - Plumbing Piping.
- D Drawings indicate general arrangement of piping, fittings, and specialties.
- E Where installing piping adjacent to domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 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 system, equipment, and piping work with applicable electrical, fuel, gas, vent, drain, and waste support interconnections as included or provided by other trades.
- D 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.

3.4 ELECTRICAL CONNECTIONS

- A Connect wiring according to Division 26 - Low-Voltage Electrical Power Conductors and Cables.
- B Ground equipment according to Division 26 - Grounding and Bonding for Electrical Systems.
- C Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.5 IDENTIFICATION

- A Identify system components. Comply with requirements for identification specified in Section 220553 - Identification for Plumbing Piping and Equipment.

3.6 FIELD QUALITY CONTROL

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- A See Division 01 Quality Requirements for additional requirements.
- B Testing Agency: -MAKE A SELECTION- a qualified testing agency to perform tests and inspections.
- C Manufacturer's Field Service, Including Testing: Engage a factory-authorized service representative to -MAKE A SELECTION- field tests and inspections.
- D Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E Domestic-water heaters will be considered defective if they do not pass tests and inspections.
- F Processed-water system will be considered defective if it does not pass tests and inspections.
- G Prepare test and inspection reports.

3.7 MAINTENANCE SERVICE - WATER SOFTENER

- A Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include -MAKE A SELECTION- months' full maintenance by skilled employees of water softener Installer. Include -MAKE A SELECTION- preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper water softener operation at rated capacity. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
- B Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

3.8 DEMONSTRATION

- A Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain domestic-water heaters.

END OF SECTION 223000

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SECTION 224000
PLUMBING FIXTURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Flush valve water closets.
- B Wall hung urinals.
- C Lavatories.
- D Sinks.
- E Bathtubs
- F Showers.
- G Electric water coolers.
- H Mop sinks.

1.2 RELATED REQUIREMENTS

- A Division 01 - Summary: Owner-furnished fixtures.
- B Division 06 - Architectural Wood Casework: Counters for sinks and lavatories.
- C Division 07 - Joint Sealants: Sealing joints between fixtures and walls and floors.
- D Division 11 - Foodservice Equipment: Food service sinks.
- E Division 11 - Foodservice Equipment: Laboratory sinks.
- F Division 12 - Countertops: Counters for sinks and lavatories.
- G Section 221005 - Plumbing Piping.

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- H Section 221006 - Plumbing Piping Specialties.
- I Section 223000 - Plumbing Equipment.
- J Section 224300 - PENDING REVIEW - Healthcare Plumbing Fixtures
- K Section 224500 - Emergency Plumbing Fixtures.
- L Section 220719 - Plumbing Piping and Equipment Insulation.
- M Division 26 - Wiring Connections:: Electrical characteristics and wiring connections.

1.3 REFERENCE STANDARDS

- A ASME A112.6.1M - Floor-Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use; 1997 (Reaffirmed 2017).
- B ASME A112.6.2 - Framing-Affixed Supports (Carriers) for Off-the-Floor Plumbing Fixtures; 2017 (R2022).
- C ASME A112.18.1 - Plumbing Supply Fittings; 2024.
- D ASME A112.18.3 - Performance Requirements for Backflow Devices and Systems in Plumbing Fixture Fittings; 2002 (R2022).
- E ASME A112.19.1 - Enamelled Cast Iron and Enamelled Steel Plumbing Fixtures; 2024.
- F ASME A112.19.2 - Ceramic Plumbing Fixtures; 2024.
- G ASME A112.19.3 - Stainless Steel Plumbing Fixtures; 2022.
- H ASME A112.19.1 - Enamelled Cast Iron and Enamelled Steel Plumbing Fixtures; 2024.
- I ASME A112.19.5 - Flush Valves and Spuds for Water Closets, Urinals, and Tanks; 2022.
- J ASSE 1016 - Performance Requirements for Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations; 2017 (Reaffirmed 2021).
- K ASSE 1016/ASME A112.1016 - Performance requirements for automatic compensating valves for individual showers and tub/shower combinations; 2017.

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- L ASSE 1037/ASME A112.1037/CSA B125.37 - Performance Requirements for Pressurized Flushing Devices for Plumbing Fixtures; 2020.
- M ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices; 2020.
- N IAPMO Z124 - Plastic Plumbing Fixtures; 2022, with Editorial Revision.
- O IAPMO/ANSI Z124.5 - Plastic Toilet Seats; 2013.
- P ICC A117.1 - Accessible and Usable Buildings and Facilities; 2017.
- Q NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- R NSF 61 - Drinking Water System Components - Health Effects; 2024.
- S NSF 372 - Drinking Water System Components - Lead Content; 2024.
- T UL (DIR) - Online Certifications Directory; Current Edition.

1.4 DEFINITIONS

- A FRP: Fiberglass-reinforced plastic.
- B High-Efficiency Water Closet Flush Volume: 1.28 gal (4.8 L) or less per flush.
- C PMMA: Polymethyl methacrylate; also known as "acrylic."
- D Standard-Efficiency Water Closet Flush Volume: 1.6 gal (6 L) per flush.
- E WaterSense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the WaterSense performance criteria.

1.5 SUBMITTALS

- A Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- B Manufacturer's Instructions: Indicate installation methods and procedures.

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- C Design Documentation: Submit appropriate evidence that materials used in potable water systems comply with the specified requirements.
- D Maintenance Data: Include fixture trim exploded view and replacement parts lists.
- E Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section.

1.7 DELIVERY, STORAGE, AND HANDLING

- A Accept fixtures on-site in factory packaging. Inspect for damage.
- B Protect installed fixtures from damage by securing areas and by leaving factory packaging in place to protect fixtures and prevent use.

1.8 WARRANTY

- A See Division 01 - Closeout Submittals for additional warranty requirements.
- B Provide one year manufacturer warranty for Plumbing Fixtures.
- C Provide five year manufacturer warranty for Electric Water Cooler Refrigeration System.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A Potable Water Systems: Provide plumbing fittings and faucets that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.
- B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C Maximum Fixture or Faucet Supply Pressure: 80 psi (5.4 bar) unless stated otherwise.

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- D Drinking fountains, water coolers, bottle filling stations, and remote water coolers intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of the authority having jurisdiction, and with NSF 61 or NSF 372, or be certified in compliance with NSF 61 or NSF 372 by an ANSI-accredited third-party certification body, that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 SOURCE LIMITATIONS

- A Obtain each product type from single manufacturer.

2.3 REGULATORY REQUIREMENTS

- A Comply with applicable codes for installation of plumbing systems.
- B Comply with UL (DIR) requirements.
- C Perform work in accordance with local health department regulations.
- D Provide certificate of compliance from Authority Having Jurisdiction indicating approval of installation.

2.4 FLUSH VALVE WATER CLOSETS

- A Water Closets: WC
 1. Refer to Schedule on drawings.
 2. Vitreous china, ASME A112.19.2, siphon jet flush action.
 3. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard, Inc
 - b. Kohler Company
 - c. Sloan Valve Company
 - d. TOTO USA, INC
 - e. Zurn Industries, LLC
- B Flush Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard, Inc
 - b. Sloan Valve Company
 - c. Zurn Industries, LLC
 2. Refer to Schedule on drawings
 3. Standard: ASSE 1037/ASME A112.1037/CSA B125.37

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C Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard, Inc
 - b. Bemis Manufacturing Company
 - c. Centoco Manufacturing Corporation
 - d. Church Seat Company
 - e. Kohler Co
 - f. Olsonite
 - g. TOTO USA, INC
 - h. Zurn Industries, LLC
2. Refer to Schedule on drawings
3. Standard: IAPMO/ANSI Z124.5.

D Water Closet Carriers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Jay R. Smith Manufacturing Company
 - b. JOSAM Company
 - c. MIFAB, Inc
 - d. Wade; a subsidiary of McWane Inc.
 - e. WATTS; A Watts Water Technologies Company
 - f. Zurn Industries, LLC
2. Refer to Schedule on drawings.
3. Standard: ASME A112.6.1M.

2.5 WALL HUNG URINALS

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. American Standard, Inc
2. Kohler Company
3. Sloan Valve
4. TOTO USA, INC
5. Zurn Industries, LLC

B Refer to Schedule on drawings.

C Fixture Standards: ASME A112.19.2 and ASME A112.19.5

D Flush Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard, Inc

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- b. Sloan Valve Company
- c. Zurn Industries, LLC
- 2. Refer to Schedule on drawings.
- 3. Standard: ASSE 1037/ASME A112.1037/CSA B125.37 and ASME A112.19.5

E Urinal Carriers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Jay R. Smith Manufacturing Company
 - b. MIFAB, Inc
 - c. Wade; a subsidiary of McWane Inc.
 - d. WATTS; A Watts Water Technologies Company
 - e. Zurn Industries, LLC
- 2. Refer to Schedule on drawings.
- 3. Standard: ASME A112.6.1M.

2.6 LAVATORIES

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

- 1. American Standard, Inc
- 2. Kohler Company
- 3. Sloan Valve Company
- 4. TOTO USA, INC
- 5. Zurn Industries, LLC

B Wall-Hung Basin:

- 1. Refer to Schedule on drawings.
- 2. Vitreous China: ASME A112.19.2
- 3. Carrier:
 - a. Refer to Schedule on drawings
 - b. Standard: ASME A112.6.1M or ASME A112.6.2.
 - c. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1) Jay R. Smith MFG. Co
 - 2) MIFAB, Inc
 - 3) Wade; a subsidiary of McWane Inc.
 - 4) WATTS; A Watts Water Technologies Company
 - 5) Zurn Industries, LLC

C Drop-In Basin:

- 1. Refer to Schedule on drawings.
- 2. Porcelain on Steel: ASME A112.19.1
- 3. Vitreous China: ASME A112.19.2

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- D Under-Mount Basin:
1. Refer to Schedule on drawings
 2. Vitreous China: ASME A112.19.2
- E Supply Faucet:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard, Inc
 - b. Chicago Faucets; Geberit Group
 - c. Delta Faucet Company
 - d. Elkay
 - e. Kohler Company
 - f. Moen Incorporated
 - g. Sloan Valve Company
 - h. T&S Brass and Bronze Works, Inc.
 - i. Zurn Industries, LLC
 2. Refer to Schedule on drawings.
 3. Standard: ASME A112.18.1
- F Thermostatic Mixing Valve:
1. ASSE 1070 listed with combination stop, strainer, and check valves, and flexible stainless steel connectors.
 2. Refer to Schedule on drawings.

2.7 SINKS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Advance Tabco
 2. American Standard, Inc
 3. Eagle Group
 4. Elkay
 5. Just Manufacturing
 6. Kohler Company
- B Stainless Steel
1. Refer to Schedule on drawings
 2. Standard: ASME A112.19.3
- C Kitchen Faucets:
1. Manufacturers:
 - a. American Standard, Inc
 - b. Chicago Faucets; Geberit Group
 - c. Elkay

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- d. Just Manufacturing
 - e. Kindred
 - f. Kohler Co
 - g. Moen Incorporated
 - h. Sloan Valve Company
 - i. T&S Brass and Bronze Works, Inc.
 - j. Zurn Industries, LLC
2. Refer to Schedule on drawings.

- D Accessories: Provide braided water supply lines, stainless steel basket strainer, and 17 GA Chrome Plated Brass P-Trap.

2.8 BATHTUBS

- A Shower Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

- 1. American Standard, Inc
- 2. Aqua Bath Company, Inc.
- 3. Aquatic
- 4. Crane Plumbing, LLC; a division of American Standard
- 5. Eljer, Inc.
- 6. Florestone Products Co., Inc.
- 7. Kohler Company

- B Refer to Schedule on drawings.

- C Bathtubs - Metal:

- 1. Standard: ASME A112.19.1

- D Bathtub - Plastic:

- 1. Standard: IAPMO Z124

- E Bathtub Faucets:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard
 - b. Chicago Faucets
 - c. Delta
 - d. Kohler
 - e. Lawler
 - f. T&S Brass
- 2. Refer to Schedule on drawings.
- 3. Standard: ASME A112.18.1 and ASSE 1016/ASME A112.1016

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2.9 SHOWERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. American Standard, Inc
 - 2. Aqua Bath Company, Inc.
 - 3. Aquatic
 - 4. Florestone Products Co., Inc.
 - 5. Freedom Showers
 - 6. Kohler Company

- B Refer to Schedule on drawings.

- C Standards: IAPMO/ANSI Z124.1.2 and ICC A117.1 for roll-in shower compartments.

- D Shower Trim:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard
 - b. Delta
 - c. Kohler
 - d. Lawler Manufacturing Company, Inc
 - e. Moen Incorporated
 - f. POWERS; A Watts Water Technologies Company
 - g. Speakman Company
 - h. Symmons Industries, Inc
 - i. T&S Brass and Bronze Works, Inc.
 - j. Watts
 - k. Zurn Industries, LLC
 - 2. Refer to Schedule on drawings.
 - 3. Standard: ASME A112.18.1
 - 4. Provide Handheld Shower Head with ASME A112.18.3 Backflow Preventor and slide bar.
 - 5. Provide with Manufacturer's Seat and Grab Bars to comply with ADA requirements.

- E Low-Flow Shower Head:
 - 1. ASME A112.18.1; chrome-plated vandal-proof institutional head with integral wall bracket, built-in 1.5 gpm (0.094 L/s) flow control.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. American Standard
 - b. Delta
 - c. Kohler
 - d. Lawler Manufacturing Company, Inc
 - e. Moen Incorporated
 - f. POWERS; A Watts Water Technologies Company

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- g. Speakman Company
- h. Symmons Industries, Inc
- i. T&S Brass and Bronze Works, Inc.
- j. Watts
- k. Zurn Industries, LLC

2.10 ELECTRIC WATER COOLERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Elkay Manufacturing Company
 - 2. Halsey Taylor
 - 3. Haws Corporation
 - 4. Oasis International
- B Refer to Schedule on drawings.
- C Electric water cooler Standards: -MAKE SELECTIONS-.
- D Filter Standards: NSF 42 and NSF 53.
- E Cooling System Standards: ASHRAE 18 and UL 399.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F Bottle Filler: Materials to match fountain.

2.11 MOP SINKS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Acorn Engineering Company
 - 2. Elkay
 - 3. E.L. Mustee & Sons
 - 4. Fiat Products
 - 5. Florestone Products Co., Inc.
 - 6. Just Manufacturing Company
 - 7. Stern-Williams Products, LLC.
 - 8. Zurn Industries, LLC
- B Refer to Schedule on drawings

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C Standards: -MAKE SELECTIONS-.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that walls and floor finishes are prepared and ready for installation of fixtures.
- B Verify that electric power is available and of the correct characteristics.
- C Confirm that millwork is constructed with adequate provision for the installation of counter top lavatories and sinks.
- D Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.
- E Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A Rough-in fixture piping connections in accordance with minimum sizes indicated in fixture rough-in schedule for particular fixtures.

3.3 INSTALLATION

- A Install each fixture with trap, easily removable for servicing and cleaning.
- B Provide chrome-plated rigid or flexible supplies to fixtures with loose key stops, reducers, and escutcheons.
- C Install components level and plumb.
- D Install and secure fixtures in place with wall carriers and bolts.
- E Solidly attach water closets to floor with lag screws. Lead flashing is not intended to hold fixture in place.
- F Install supports, affixed to building substrate, for wall-mounted fixtures.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.

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3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- G Install water-supply piping with stop on each supply to each fixture to be connected to water-distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 1. Exception for use of ball valve if supply stops are not specified with fixture. Comply with valve requirements specified in Section 220523 "General Duty Valve for Piping."
- H Install dielectric fitting in supply piping to equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221005 - Plumbing Piping.
- I Fill self-contained fixtures with flushing fluid.
- J Lavatory Installation:
 1. Install lavatories level and plumb in accordance with roughing-in drawings.
 2. Install supports, affixed to building substrate, for wall-mounted lavatories.
 3. Install accessible, wall-mounted lavatories at mounting height in accordance with the architectural drawings and ICC A117.1.
 4. Install water-supply piping with stop on each supply to each lavatory faucet. Install stops in locations that are accessible for ease of operation.
 5. Install trap and waste piping on each drain outlet of each lavatory to be connected to sanitary drainage system.
 6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 - Common Work Results for Plumbing.
 7. Install counter-mounting fixtures in and attached to casework.
 8. Install pedestal lavatories on pedestals and secured to wood blocking in wall.
 9. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section Division 07 - Joint Sealants.
 10. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 - Plumbing Piping Insulation.
 11. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
 12. Install laminar-flow, faucet-spout fittings in faucet spouts where laminar-flow fittings are specified.
- K Shower Installation:
 1. Assemble shower components in accordance with manufacturers' written instructions.
 2. Install showers level and plumb in accordance with roughing-in drawings.

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3. Install ball valves in water-supply piping to the shower if supply stops are not specified with the shower valve. Comply with ball valve requirements specified in Section 220523 - General Duty Valves for Plumbing Piping. Install valves in locations that are accessible for ease of operation.
4. Install shower flow-control fittings with specified maximum flow rates in shower arms.
5. Set MAKE SELECTIONS -MAKE SELECTIONS- in leveling bed of cement grout.
6. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 - Common Work Results for Plumbing.
7. Showers, except Cast-Polymer Showers: Seal joints between showers, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section Division 07 - Joint Sealants.
8. Cast-Polymer Showers: Adhere panels to drywall using shower manufacturer's recommended adhesive. Seal joints, between panels and between panels and adjacent drywall, using shower manufacturer's recommended caulking specific for each application. Match sealant to fixture color.

L Sink Installation:

1. Install sinks level and plumb in accordance with roughing-in drawings.
2. Install supports, affixed to building substrate, for wall-mounted sinks.
3. Install accessible, wall-mounted sinks at mounting height in accordance with the architectural drawings and ICC A117.1.
4. Set floor-mounted sinks in leveling bed of cement grout.
5. Install water-supply piping with stop on each supply to each sink faucet.
 - a. Exception: Use ball valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523 - General Duty Valves for Plumbing Piping."
 - b. Install stops/valves in locations that are accessible for ease of operation.
6. Install trap and waste piping on each drain outlet of each sink to be connected to sanitary drainage system.
7. Install disposer in outlet of each sink indicated to have a disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.
8. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 - Common Work Results for Plumbing."
9. Seal joints between sinks, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section Division 07 - Joint Sealants.
10. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 - Plumbing Piping Insulation.
11. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
12. Install laminar-flow, faucet-spout fittings in faucet spouts where laminar-flow fittings are specified.

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M Urinal Installation:

1. Install urinals level and plumb in accordance with roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste-fitting seals and attached to supports.
3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
4. Install accessible, wall-mounted urinals at mounting height in accordance with the architectural drawings and ICC A117.1.
5. Install supports, affixed to building substrate, for wall-hung urinals.
6. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
7. Use carriers without waste fitting for urinals with tubular waste piping.
8. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.
9. Measure support height installation from finished floor, not structural floor.
10. Install flushometer valve, water-supply fitting on each supply to each urinal.
11. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
12. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
13. Install actuators in locations easily reachable for people with disabilities.
14. Install new batteries in battery-powered, electronic-sensor mechanisms.
15. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 - Common Work Results for Plumbing."
16. Seal joints between urinals, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to urinal color. Comply with sealant requirements specified in Section Division 07 - Joint Sealants.

N Water Closet Installation:

1. Install water closets level and plumb in accordance with roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height in accordance with the architectural drawings and ICC A117.1.
4. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
5. Use carrier supports with waste-fitting assembly and seal.
6. Install floor-mounted, back-outlet water closets, attached to building floor substrate, onto waste-fitting seals; and attach to support.
7. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals, and affix to building substrate.
8. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.
9. Measure support height installation from finished floor, not structural floor.
10. Install flushometer-valve, water-supply fitting on each supply to each water closet.
11. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
12. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
13. Install actuators in locations easily reachable for people with disabilities.
14. Install new batteries in battery-powered, electronic-sensor mechanisms.
15. Install toilet seats on water closets.

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16. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Install deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220500 - Common Work Results for Plumbing.
17. Seal joints between water closets, walls, and floors using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to water-closet color. Comply with sealant requirements specified in Section Division 07 - Joint Sealants.

3.4 INSTALLATION OF PIPING CONNECTIONS

- A Connect plumbing fixtures with water supplies and soil, waste, and vent piping. Use size fittings required to match plumbing fixtures.
- B Comply with water, soil, waste, and vent piping requirements specified in Section 221005 "Plumbing Piping."
- C Install protective-shielding pipe covers and enclosures on exposed supplies and waste piping of accessible plumbing fixtures. Comply with requirements in Section 220719 "Plumbing Piping Insulation."
- D Where installing piping adjacent to water closets and urinals, allow space for service and maintenance.
- E Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.5 INSTALLATION OF ELECTRICAL CONNECTIONS

- A Connect wiring in accordance with Division 26.
- B Ground equipment in accordance with Division 26.
- C Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70.
- D Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Division 26 Section - Identification for Electrical Systems.
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

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3.6 INSTALLATION OF CONTROL CONNECTIONS

- A Install control and electrical power wiring to field-mounted control devices.
- B Connect control wiring in accordance with Division 26.

3.7 INTERFACE WITH WORK OF OTHER SECTIONS

- A Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.

3.8 ADJUSTING

- A Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.
- B Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning plumbing fixtures, fittings, and controls.
- C Adjust water pressure at faucets to produce proper flow.
- D Adjust water pressure at shower valves to produce proper flow.
- E Adjust water pressure at flushometer valves to produce proper flow.
- F Install new batteries in battery-powered, electronic-sensor mechanisms.

3.9 CLEANING

- A Clean plumbing fixtures and equipment.
- B After completing installation of plumbing fixtures, inspect and repair damage to finishes. Replace any fixtures unable to be repaired to the satisfaction of the Architect.
- C Clean plumbing fixtures and associated faucets, valves, flushometer valves, and fittings with manufacturers' recommended cleaning methods and materials.
- D Provide protective covering for installed plumbing fixtures and associated faucets, valves, flushometer valves, and fittings.

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- E Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.
- F See Division 01 - Construction Waste Management and Disposal for additional requirements.

3.10 PROTECTION

- A Protect installed products from damage due to subsequent construction operations.
- B Do not permit use of fixtures by construction personnel.
- C Repair or replace damaged products before Date of Substantial Completion.

3.11 SCHEDULES

- A Contractor shall coordinate the following fixture heights with the architectural drawings and the local accessibility code. fixture heights indicated in the architectural drawings and the local accessibility code shall take precedence
- B Fixture Heights: Install fixtures to heights above finished floor as indicated.
 - 1. Water Closet:
 - a. Standard: 15 inches (380 mm) to top of bowl rim.
 - b. Accessible: 17 to 19 inch (431.8 to 482.6 mm) to top of seat.
 - 2. Water Closet Flush Valves:
 - a. Standard: 11 inches (280 mm) min. above bowl rim.
 - b. Recessed: 10 inches (255 mm) min. above bowl rim.
 - 3. Urinal:
 - a. Standard: 22 inches (560 mm) to top of bowl rim.
 - b. Accessible: 17 inches (430 mm) to top of bowl rim.
 - 4. Lavatory:
 - a. Standard: 31 inches (785 mm) to top of basin rim.
 - b. Accessible: 34 inches (865 mm) to top of basin rim.
 - 5. Drinking Fountain:
 - a. Child: 30 inches (760 mm) to top of basin rim.
 - b. Standard Adult: 40 inches (1015 mm) to top of basin rim.
 - c. Accessible: 36 inches (915 mm) to top of spout.
 - 6. Shower Heads:
 - a. Adult Male: 69.5 inches (1765 mm) to bottom of head.
 - b. Adult Female: 64.5 inches (1640 mm) to bottom of head.
 - c. Child: 58.5 inches (1490 mm) to bottom of head.

END OF SECTION 224000

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SECTION 224500
EMERGENCY PLUMBING FIXTURES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Emergency shower.
- B Eyewash equipment.
- C Personal eyewash equipment.
- D Eye/face wash equipment.
- E Hand-held emergency drench hose.
- F Safety stations (combination emergency fixture units).
- G Emergency-fixture water-tempering valves.

1.2 REFERENCE STANDARDS

- A ANSI Z358.1 - American National Standard for Emergency Eyewash and Shower Equipment; 2014.
- B ASME A112.18.1 - Plumbing Supply Fittings; 2024.
- C ASME A112.18.2 - Plumbing Waste Fittings; 2020.
- D ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices; 2020.
- E ASSE 1071 - Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment; 2012 (R2021).
- F ICC A117.1 - Accessible and Usable Buildings and Facilities; 2017.
- G NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

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H NSF 61 - Drinking Water System Components - Health Effects; 2024.

I NSF 372 - Drinking Water System Components - Lead Content; 2024.

1.3 SUBMITTALS

A See Section Division 01 - Administrative Requirements for submittal procedures.

B Product Data: Manufacturer's catalog sheets for fixtures, fittings, accessories, and supplies.

C Field Test Reports: Plumbing fixture operational tests.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A Comply with ANSI Z358.1 for emergency plumbing fixtures including third-party certification of fixtures.

B Comply with ASSE 1071 for temperature-actuated mixing valves for plumbed emergency fixtures.

C Comply with ASME A112.18.1/CSA B125.1 for water-supply fittings.

D Comply with ASME A112.18.2/CSA B125.2 for plumbing waste fittings.

E Comply with NSF 61 and NSF 372 for fixture materials that will be in contact with potable water.

F Comply with requirements in ICC A117.1 for plumbing fixtures for people with disabilities.

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

2.2 SOURCE LIMITATIONS

A Obtain each product type from single manufacturer.

2.3 EMERGENCY SHOWER

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- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Acorn Safety; a Division of Morris Group International
 2. Bradley Corporation
 3. Encon Safety Products, Inc
 4. Guardian Equipment
 5. Haws Corporation; _____
 6. Hughes a company of Justrite Group
 7. Justrite Manufacturing Company, LLC
 8. Sellstrom Manufacturing Company
 9. Speakman Company
 10. Stingray Systems LLC
 11. Sysbel
 12. Therm-Omega-Tech, Inc
 13. WaterSaver Faucet Co
- B Refer to Schedule on drawings.
- C ANSI Z358.1, -MAKE A SELECTION-, drench type-MAKE A SELECTION-.
- D Tepid Supply Water Temperature: Set to 85 degrees F (29 degrees C).
- E Pipe and Fittings Material: Epoxy coated galvanized steel.
- F Shower Head:
1. Type: Self-cleaning, non-clogging, 8 inches (20 cm) in diameter.
- G Freeze Protection: Remote-mounted, thermostatically-actuated bleed valve.
- H Valve: Full flow, self closing, quick to open using assembly-fitted manual arm-rod based hand operator.
- I Thermostatic Mixing Valve:
1. ASSE 1071 listed with combination stop, strainer, check valve, and flexible stainless steel connectors.

2.4 EYEWASH EQUIPMENT

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Bradley Corporation
 2. Encon Safety Products, Inc
 3. Guardian Equipment

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4. Haws Corporation
5. Hughes a company of Justrite Group
6. Justrite Manufacturing Company, LLC
7. Speakman Company
8. Stingray Systems LLC
9. Sysbel
10. WaterSaver Faucet Co

B ANSI Z358.1, wall-mounted bowl with dual eye-spray head assembly.

C Tepad Supply Water Temperature: Set to 85 degrees F (29 degrees C).

D Pipe and Fittings Material: Epoxy coated galvanized steel.

E Freeze Protection: -MAKE A SELECTION-.

F Valve: Full flow, self close, quick to open using wide-handle manual hand operator.

G Drain: Built-into the bowl assembly with 1-1/4 inch (3.2 cm) female outlet.

2.5 PERSONAL EYEWASH EQUIPMENT

A Wall-mounted, emergency labeled eye wash station with one-16 oz (0.94 liter) bottled fluid saline solution.

B Portable emergency labeled eye wash travel pack with six-4 oz (0.12 liter) and six-1 oz (0.03 liter) bottled fluid saline solution.

2.6 EYE/FACE WASH EQUIPMENT

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Acorn Safety; a Division of Morris Group International
2. Bradley Corporation
3. Encon Safety Products, Inc; _____
4. Guardian Equipment
5. Haws Corporation
6. Hughes a company of Justrite Group
7. Justrite Manufacturing Company, LLC
8. Sellstrom Manufacturing Company
9. Speakman Company
10. Stingray Systems LLC

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11. Sysbel
12. Therm-Omega-Tech, Inc
13. WaterSaver Faucet Co

B Refer to Schedule on drawings.

C ANSI Z358.1, -MAKE A SELECTION- dual eye-spray head assembly.

D Pipe and Fittings Material: PVC.

E Freeze Protection: -MAKE A SELECTION-.

F Valve: Full flow, self closing, quick to open thru wide-handle manual hand operator.

G Drain: Built-into the bowl assembly with 1-1/4 inch (3.2 cm) female outlet.

H Thermostatic Mixing Valve:

1. ASSE 1071 listed with combination stop, strainer, check valve, and flexible stainless steel connectors.

2.7 HAND-HELD EMERGENCY DRENCH HOSE

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Acorn Safety; a Division of Morris Group International
2. Bradley Corporation
3. Encon Safety Products, Inc
4. Guardian Equipment; _____
5. Haws Corporation
6. Justrite Manufacturing Company, LLC
7. Speakman Company
8. Sysbel
9. WaterSaver Faucet Co

B Refer to Schedule on drawings.

C ANSI Z358.1, 15 gallon (57 liter) drench hose with flanged spray head assembly.

D Hose:

1. 8 feet (2.4 m) long, flexible reinforced PVC with fitted male swivel water connection.
2. Maximum Working Pressure: 275 psi (18.9 bar).

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E Handle: Full flow, self closing, quick to open plastic covered metal lever handle.

F Tepid Supply Water Temperature: Set to 95 degrees F (35 degrees C).

2.8 SAFETY STATIONS (COMBINATION EMERGENCY FIXTURE UNITS)

A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.

1. Acorn Safety; a Division of Morris Group International
2. B-L-S Industries, Inc
3. Bradley Corporation
4. Encon Safety Products, Inc
5. Guardian Equipment
6. Haws Corporation
7. Hughes a company of Justrite Group
8. Justrite Manufacturing Company, LLC
9. Sellstrom Manufacturing Company
10. Speakman Company
11. Stingray Systems LLC
12. Sysbel; _____
13. Therm-Omega-Tech, Inc
14. WaterSaver Faucet Co

B Refer to Schedule on drawings.

C Standards: ANSI Z358.1.

D Thermostatic Mixing Valve: Thermostatic mixing valve, ASSE 1071 listed, with combination stop, strainer, and check valves, and flexible stainless steel connectors.

E Heating System: Electric, 120 V ac; insulation enclosed in a protective jacket with thermometer.

1. Heating Capacity: 10 deg F (6 deg C) minimum above ambient temperature.

F Tepid Supply Water Temperature: Set to 85 degrees F (29 degrees C).

G Pipe and Fittings Material: Powder coated galvanized steel.

H Shower Head:

1. Self-cleaning, non-clogging, 10 inches (25.4 cm) in diameter with escutcheon.
2. Flow Pattern: Minimum, 20 inches (50.8 cm) at 60 inches (152.4 cm) above floor end.

I Freeze Protection: -MAKE A SELECTION-.

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- J Valves: Full flow, self closing, quick to open within one second using dedicated manual panic bar operator for shower and dedicated manual panic bar handle for eye wash.

2.9 EMERGENCY-FIXTURE WATER-TEMPERING VALVES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Bradley Corporation; _____: www.bradleycorp.com/#sle.
 2. Encon Safety Products, Inc; _____: www.enconsafety.com/#sle.
 3. ESBE; _____: www.esbe.eu/global/en/#sle.
 4. Guardian Equipment; _____: www.gesafety.com/#sle.
 5. Haws Corporation; _____: www.hawesco.com/#sle.
 6. Speakman Company; _____: www.speakman.com/#sle.
 7. Therm-Omega-Tech, Inc; _____: www.thermomegatech.com/#sle.
- B Refer to Schedule on drawings.
- C Tepid Water Temperature: Set to 85 degrees F (29 degrees C).
- D Valve Assembly: Thermostatic mixing (blending) type made of -MAKE A SELECTION- with integral -MAKE SELECTIONS-.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that fixtures and accessories are of the correct type and size prior to installation.
- B Verify that deck, wall and floor finishes are prepared and ready for fixture installation.
- C Examine roughing-in for piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.
- D Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
- B Install fixtures level and plumb.

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- C Fasten fixtures to substrate.
- D Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523 - General-Duty Valves for Plumbing Piping
 - 1. Exceptions:
 - a. Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
 - b. Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
- E Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220500 - Common Work Results for Plumbing.
- F Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221005 - Plumbing Piping.
- G Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221005 - Plumbing Piping.

END OF SECTION 224500

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SECTION 226000
GAS AND VACUUM SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe, tube, and fittings.
- B. Valves.
- C. Regulators and flowmeters.
- D. Manifolds.
- E. Outlets.
- F. Air compressors.
- G. Vacuum pumps.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 078400 - Firestopping.
- C. Section 220517 - Sleeves and Sleeve Seals for Plumbing Piping.
- D. Section 220529 - Hangers and Supports for Plumbing Piping and Equipment - PENDING APPROVAL.
- E. Section 220553 - Identification for Plumbing Piping and Equipment.
- F. Section 312316 - NOT OEC EDITED - Excavation.
- G. Section 312323 - NOT OEC EDITED - Fill.

1.03 ABBREVIATIONS AND ACRONYMS

- A. CC: Cubic centimeters per minute.
- B. CGA: Compressed Gas Association.

1.04 REFERENCE STANDARDS

- A. ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges; 2021.
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2021.
- C. ASME B16.24 - Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500; 2021.
- D. ASME B16.50 - Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings; 2021.
- E. ASME B18.2.1 - Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series); 2012 (Reaffirmed 2021).
- F. ASME B31.1 - Power Piping; 2024.
- G. ASME B31.9 - Building Services Piping; 2020.
- H. 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.
- I. ASTM B32 - Standard Specification for Solder Metal; 2020.

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- J. ASTM B813 - Standard Specification for Water Flushable Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube; 2024.
- K. ASTM B819 - Standard Specification for Seamless Copper Tube for Medical Gas Systems; 2019.
- L. ASTM F2014 - Standard Specification for Non-Reinforced Extruded Tee Connections for Piping Applications; r24.
- M. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.
- N. AWS B2.2/B2.2M - Specification for Brazing Procedure and Performance Qualification; 2016.
- O. CGA V-1 - Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections; 2023.
- P. CGA V-5 - Standard for Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications); 2019.
- Q. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2018, with Amendment (2019).
- R. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010, with Errata .
- S. MSS SP-123 - Non-Ferrous Threaded and Solder-Joint Unions for Use With Copper Water Tube; 2018.
- T. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- U. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- V. NEMA IA 10030 - Industrial Control and Systems: Enclosures; 2024.
- W. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2008 (Reaffirmed 2020).
- X. NFPA 55 - Compressed Gases and Cryogenic Fluids Code; 2023, with Amendment .
- Y. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- Z. NFPA 99 - Health Care Facilities Code; 2024, with Errata.
- AA. UL (DIR) - Online Certifications Directory; Current Edition.
- BB. UL 508 - Industrial Control Equipment; Current Edition, Including All Revisions.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's literature and data sheets for each product. Include capacities, configurations, dimensions, finishes, weights, service condition requirements, and installed features.
 - 1. Include sound level data for the following:
 - a. Compressors.
 - b. Vacuum pumps.
 - c. Nitrogen Generator.
- C. Shop Drawings: Provide for products listed below. Indicate general assembly of components, mounting and installation details, unit dimensions, required clearances, construction details, field piping connection details, and electrical characteristics and connection requirements.

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1. Manifolds: Include dimensioned plans and elevations showing manifold, header assemblies, and cylinder arrangements.
2. Outlets: Include elevation drawings showing arrangements of laboratory outlet wall assemblies.
- D. Independent Inspection, Testing, and Verification Agency Reports: Documentation of inspection, testing, and verification results showing system compliance with NFPA 99.
- E. Manufacturer's Instructions: Provide for products listed below. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
 1. Corrugated medical tubing.
 2. Regulators.
 3. Flowmeters.
 4. Manifolds.
 5. Outlets.
 6. Compressors.
 7. Vacuum pumps.
- F. Manufacturer's qualifications statement.
- G. Installer's qualifications statement.
- H. Inspector's qualification statement.
- I. Testing and verification company's qualification statement.
- J. Operation and Maintenance Data: For each product, provide manufacturers installation, operating, testing, and maintenance instructions.
- K. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- L. Project Record Documents: Complete set of floor plans showing actual installed locations of components, equipment, tanks, cylinders, piping, and valving. See Section 017800 for additional requirements.

1.06 QUALITY ASSURANCE

- A. Laboratory Gas Systems: Select products and execute work in compliance with NFPA 55.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with at least three years of documented experience.
- C. Installer Qualifications: Company specializing in performing work of type specified and with at least five years of documented experience.
 1. Brazing: Qualified in accordance with ASME BPVC-IX or AWS B2.2/B2.2M.
- D. Inspector Qualifications: Company specializing in performing testing of type specified in this section, with minimum five years of documented experience.
- E. Testing and Verification Qualifications: Company specializing in performing testing of type specified in this section, with minimum five years of documented experience.
- F. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

1.07 WARRANTY

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

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PART 2 PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

- A. Laboratory Gases:
 - 1. General Requirements:
 - a. Pipe, tube, and fittings cleaned by manufacturer in accordance with CGA G-4.1.
 - b. Pipe ends and tube ends factory capped or plugged by manufacturer prior to shipping and kept sealed until time of installation.
 - c. Fittings sealed and labeled prior to shipping and kept sealed until time of installation.
 - d. Comply with ASME B31.1 for laboratory air piping operating at more than 150 psig (1035 kPa).
 - e. Comply with ASME B31.9 for laboratory air piping operating at 150 psig (1035 kPa) or less.
 - 2. Copper Pipe:
 - a. ASTM B819, seamless, drawn, Type L, factory labeled with nomenclature and colors complying with NFPA 99
 - 1) For nitrogen and instrument air systems with operating pressures in excess of 185 psig (1275 kPa) and with pipe sizes NPS 3 (DN80) and larger, use Type K.
 - b. Fittings: Wrought copper, ASME B16.22.
 - c. Joints: Brazed, AWS A5.8M/A5.8, copper-phosphorus or copper-phosphorus-silver brazing filler.
 - d. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
 - e. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
 - 1) Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos free, 1/8 inch (3 mm) maximum thickness, full-face type.
 - 2) Flange Bolts and Nuts: ASME B18.2.1 carbon steel.
 - f. Shape-Memory-Metal Couplings:
 - 1) Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy.
 - g. Copper Pressure-Seal Fittings (For Compressed Air Only):
 - 1) 2 inch (50 mm) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) 2-1/2 to 4 inch (65 to 100 mm): Bronze fitting with stainless steel grip ring and EPDM O-ring seal in each end.
 - h. Flexible Pipe Connectors (For Compressed Air Only):
 - 1) Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - (a) Working-Pressure Rating: 200 psig (1380 kPa) minimum.
 - (b) End Connections: Plain-end copper tube.
 - 3. Joining Materials
 - a. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.
 - b. Threaded-Joint Tape: PTFE.
- B. Laboratory Systems:
 - 1. Copper Pipe:
 - a. Joints: Brazed, AWS A5.8M/A5.8, copper-phosphorus or copper-phosphorus-silver brazing filler.

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- b. Wrought-Copper Fittings: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
- c. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
 - 1) Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8 inch (3.2 mm) maximum thickness, full-face type.
 - 2) Flange Bolts and Nuts: ASME B18.2.1 carbon steel.
- d. Pressure-Seal Fittings:
 - 1) 2 inch (50 mm) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 2) 2-1/2 to 4 inch (65 to 100 mm): Bronze fitting with stainless steel grip ring and EPDM O-ring seal in each end.
- e. Extruded-Tee Outlets: ASTM F2014 procedure for making branch outlets in copper tube.
 - 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
- f. Flexible Pipe Connectors:
 - 1) Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - (a) Flex-Hose Co., Inc
 - (b) Flexicraft Industries
 - (c) Metraflex Company (The)
 - (d) Universal Metal Hose
 - 2) Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - (a) Working-Pressure Rating: 200 psig (1380 kPa) minimum.
 - (b) End Connections: Plain-end copper tube.
- 2. Joining Materials
 - a. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux in accordance with ASTM B813
 - b. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.

2.02 VALVES

- A. General Requirements for Valves for Laboratory Gas Systems:
 - 1. Manufacturer cleaned in accordance with CGA G-4.1.
 - 2. Sealed, bagged, and labeled prior to shipping in accordance with CGA G-4.1 for oxygen service and kept bagged and sealed until the time of installation.
 - a. Exception: Factory cleaning and bagging are not required for valves for WAGD service.
- B. Ball Valves:
 - 1. Manufacturers:
 - a. Allied Healthcare Products, Inc
 - b. NOVAIR USA: www.novair-usa.com/#sle.
 - c. Amico Corporation
 - d. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - e. BeaconMedaes
 - f. NIBCO INC.

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- g. Ohio Medical Corporation
 - h. Tri-Tech Medical
 - 2. Three-piece, Full-port, bronze body, MSS SP-110, double-seal, with quarter-turn handle with locking device and replaceable neoprene or teflon seat and stem seals, 600 psi (4140 kPa) cold working pressure.
 - 3. Ball Valves for Laboratory Gas Systems: Provide manufacturer-installed ASTM B819 Type K copper extensions with pressure gage and with threaded purge ports on upstream and downstream sides of valve.
- C. Check Valves:
 - 1. Manufacturers:
 - a. Amico Corporation
 - b. Allied Healthcare Products, Inc.
 - c. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - d. BeaconMedaes
 - e. NIBCO INC.
 - f. Ohio Medical Corporation
 - g. Tri-Tech Medical
 - 2. Brass or bronze body, three piece, spring loaded, in-line removable and serviceable, 300 psi (2070 kPa) cold working pressure.
 - 3. Check Valves for Medical Gas Systems: Provide manufacturer-installed ASTM B819 Type K copper extensions with threaded purge ports on upstream and downstream sides of valve.
- D. Pressure Relief Valves:
 - 1. Manufacturers:
 - a. Allied Healthcare Products, Inc.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems
 - c. BeaconMedaes
 - d. NIBCO INC.
 - e. Ohio Medical Corporation
 - f. Tri-Tech Medical
 - 2. Brass, bronze, or stainless steel body, direct-acting spring relief; select valve seats appropriate to gas system type; select relief settings to suit system components and operating pressures.

2.03 REGULATORS AND FLOWMETERS

- A. General Requirements for Pressure Regulators and Flowmeters for Medical and Laboratory Gas Systems:
 - 1. Manufacturer cleaned in accordance with CGA G-4.1.
 - 2. Sealed, bagged, and labeled prior to shipping in accordance with CGA G-4.1 and kept bagged and sealed until the time of installation.
- B. Gas Pressure Regulators:
 - 1. Manufacturers:
 - a. Amico Corporation
 - b. BeaconMedaes
 - c. Harris Products Group
 - 2. Spring loaded, diaphragm type with manual pressure-adjustment knob.

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3. Body: Brass.
 4. Rated for _____ psig (_____ kPa) minimum inlet pressure.
 5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig (5.0 kPa for each 100-kPa) inlet pressure.
 6. Delivery Pressure Gauge: Dual scale, 2-inch (50 mm) diameter.
- C. Gas Flowmeters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Tri-Tech Medical
 2. Thorpe style, brass body with needle valve and graduated, labeled flow-tube in polycarbonate housing. Provide valves labeled and color coded in accordance with NFPA 99.
 3. Flow Accuracy: Plus/minus 10 percent of reading.

2.04 MANIFOLDS

- A. Duplex, Automatic Manifolds for Medical Gases:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Amico Corporation
 - b. BeaconMedaes
 2. Description: Cabinet mounted, analog, automatic switchover, automatic reset, duplex manifold to automatically changeover from primary to secondary cylinder banks and allow replacement of depleted cylinders with no change in line pressure.
 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 4. Manifold:
 - a. Constructed in accordance with NFPA 99.
 - b. Cleaned in accordance with CGA G-4.1.
 - c. Bank pressure regulators.
 - d. Redundant line-pressure regulators.
 - e. Pressure transducers.
 - f. Internal relief valves piped to common vent port.
 - g. Supply and delivery pressure gauges.
 - h. Safety valve.
 - i. Designed for 2000 psig (13.8 MPa) minimum inlet pressure, except nitrous oxide manifolds may be designed for 800 psig (5520 kPa), and carbon dioxide manifolds may be designed for 1500 psig (10.35 MPa)ue>.
 5. Headers:
 - a. Constructed in accordance with NFPA 99.
 - b. Cleaned in accordance with CGA G-4.1.
 - c. Header isolation valves.
 - d. Gas-specific cylinder pigtails complying with CGA V-1.
 - e. Arrange headers to have half of cylinders in service and half in reserve.
 - f. Individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gauge.

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6. Cabinet:
 - a. NEMA EN 10250, Type 4, lockable, with baked enamel finish.
 - b. Front-mounted analog or digital gauges indicating right bank pressure, left bank pressure, and outlet line pressure.
 7. Controls:
 - a. Analog-based to monitor cylinder pressures and initiate switchovers. Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder-bank header.
 - b. Indicator lights for each cylinder bank to show in use, ready, and empty.
 - c. Dry contacts for remote alarm annunciation.
 - d. Alarms:
 - 1) Switchover alarm or reserve-bank-in-use alarm.
 8. Mounting: Wall with mounting brackets for manifold control cabinet and headers.
 9. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.
- B. Automatic Manifolds for Specialty Laboratory Gases:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Airgas; an Air Liquide company
 - b. BeaconMedaes
 - c. CONCOA
 - d. Matheson Tri-Gas, Inc.
 - e. Amico.
 2. Description: Cabinet mounted, analog, automatic switchover, automatic reset, manifold to automatically changeover from primary to secondary cylinder banks and allow replacement of depleted cylinders with no change in line pressure.
 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 4. Manifold:
 - a. Fabrication: Brass.
 - b. Cleaned in accordance with CGA G-4.1.
 - c. Bank pressure regulators.
 - d. Line-pressure regulator.
 - e. Pressure transducer.
 - f. Internal relief valves piped to common vent port.
 - g. Designed for 2000 psig (13.8 MPa) minimum inlet pressure.
 5. Headers:
 - a. Cleaned in accordance with CGA G-4.1.
 - b. Header isolation valves.
 - c. Gas-specific cylinder pigtails.
 6. Cabinet:
 - a. NEMA EN 10250, Type 4, lockable, with baked enamel finish.
 - b. Front-mounted analog or digital gauges indicating right bank pressure, left bank pressure, and outlet line pressure.

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7. Controls:
 - a. Analog-based to monitor cylinder pressures and initiate switchovers.
 - b. Indicator lights for each cylinder bank to show in use, ready, and empty.
 - c. Dry contacts for remote alarm annunciation.
 - d. Audible alarm with manual reset.
 - e. Alarms:
 - 1) Switchover alarm or reserve-bank-in-use alarm.
8. Mounting: Wall with mounting brackets for manifold control cabinet and headers.
9. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.

2.05 OUTLETS

- A. Outlet Units:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Amico Corporation
 - b. BeaconMedaes
 - c. NOVAIR USA
 2. CGA V-5 Diameter-Index Safety System (DISS) non-interchangeable connectors, automatic valves, secondary check valves (except vacuum and evacuation outlets), and capped 3/8 inch (8 mm) tubing stubs for supply connections, color coded and labeled for intended service.
- B. General Requirements for Laboratory Gas-Service Connections:
 1. All positive-pressure gas-service connections, for all gas types, shall be manufacturer cleaned, purged, and sealed as for oxygen service in accordance with CGA G-4.1.
 2. Suitable for specific gas pressure and suction service listed.
 3. Include roughing-in assemblies, finishing assemblies, and cover plates.
 4. Recessed-type units made for concealed piping unless otherwise indicated.
- C. Faceplates:
 1. Flush Outlets: Mount in galvanized steel boxes with stainless steel faceplate with polycarbonate cover, color coded with embossed labeling.

2.06 AIR COMPRESSORS

- A. Performance Requirements
 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NFPA 99, "Health Care Facilities Code," for compressed-air equipment and accessories for medical and dental compressed-air systems.
 3. ASME Compliance: Fabricate and label receivers to comply with 2021 ASME Boiler and Pressure Vessel Code.
- B. General Requirements
 1. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
 2. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

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- a. Enclosure: NEMA IA 10030, Type 12 control panel unless otherwise indicated.
- b. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
- c. Control Voltage: 120 V ac or less, using integral control power transformer.
- d. Motor Overload Protection: Overload relay in each phase.
- e. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
- f. Automatic control switches to alternate lead-lag air compressors for duplex and sequence lead-lag air compressors for three or more air compressors.
- g. Instrumentation: Include discharge-air and receiver pressure gauges, air-filter maintenance indicator, hour meter, air compressor discharge-air and coolant temperature gauges, and control transformer.
- h. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
- i. Provide 65k AIC SCCR rating.
- 3. Receivers: Steel tank constructed in accordance with 2021 ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - a. Pressure Rating: At least as high as highest discharge pressure of connected air compressors and bearing appropriate code symbols.
 - b. Interior Finish: Corrosion-resistant coating.
 - c. Accessories: Include safety valve, pressure gauge, automatic drain, pressure regulator, and piped three-valve bypass with valves.
- 4. Mounting Frame: Fabricate base and attachment to air compressor and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.
- C. Air Compressor Packaged System - Reciprocating, Oil Less
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Amico Corporation
 - b. BeaconMedaes
 - c. Powerex, Inc.
 - 2. Refer to Schedule on drawings.
 - 3. Source Limitations: Obtain reciprocating, oil-less, air compressors from single source from single manufacturer.
 - 4. Description: Packaged system.
 - 5. Compressor(s): Single or Two-stage, oil-less (nonlubricated), reciprocating-piston type, with sealed oil-free bearings, that will deliver air of quality equal to intake air.
 - a.
 - b. Belt guard totally enclosing pulleys and belts.
 - c. Intercooler between stages of two-stage units.
 - 6. Receiver and accessories.
- D. Air Compressor Packaged System - Scroll
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Amico Corporation

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- b. BeaconMedaes
 - c. Ohio Medical Corporation
 - d. Powerex, Inc.
 - 2. Refer to Schedule on drawings.
 - 3. Source Limitations: Obtain scroll air compressors from single source from single manufacturer.
 - 4. Description: Packaged system.
 - 5. Air Compressor(s): Single-stage, oil-free, rotary, oscillating-volute type of construction that prohibits oil from entering compression chamber.
 - a. Mounting: Freestanding.
- E. Motors
- 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220500 - Common Work Results for Plumbing.

2.07 AIR COMPRESSORS - ACCESSORIES:

- A. Compressed-Air Dryers - Desiccant
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. BeaconMedaes
 - b. Ingersoll Rand
 - c. Wilkerson Operations
 - d. _____.
 - 2. Refer to Schedule on drawings.
 - 3. Source Limitations: Obtain desiccant compressed-air dryers from single source from single manufacturer.
 - 4. Description: Twin-tower unit with purge system, mufflers, and capability to deliver 10 degF (minus 12 degC), 100 psi (690 kPa) air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gauges, thermometers, automatic controls, and filters.
- B. Compressed-Air Filter Assemblies
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Ingersoll Rand
 - 2. Refer to Schedule on drawings.
 - 3. Source Limitations: Obtain compressed-air filter assemblies from single source from single manufacturer.
 - 4. Description: Filter assemblies suitable for compressed air, in parallel duplex arrangement. Size each assembly for maximum capacity of connected equipment and operating pressure of compressed-air system. Include automatic ejection of condensate from airstream, inlet and outlet pressure gauges, and shutoff valves.
 - a. Option: Factory-fabricated filter system consisting of three air filters equivalent to those specified, pipe, fittings, valves, differential pressure switch, and enclosure; and with additional automatic drain traps and gauges.
 - 5. Size filter assemblies for 5 psi (34.5 kPa) maximum air-pressure drop when filters are new and clean, at system rated capacity, and at 100 psi (690 kPa) pressure.

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6. Differential Pressure Switch: Adjustable, diaphragm type, with electrical connections for alarm system, to indicate when air-pressure drop through filters rises to more than 2 psi (13.8 kPa) greater than when new and clean.
7. Particulate Filters: Collection efficiency of 98 percent retention of particles 1 micrometer and larger.
8. Odor and Taste Filters: Vapor-absorbing, activated charcoal.
9. Coalescing Filters: Collection efficiency of 99.9 percent retention of particles 0.3 micrometer and smaller.
10. Include automatic drain trap for each filter.

2.08 NITROGEN GENERATOR

- A. Description: This section specifies the requirements for a complete, operational, on-site nitrogen generation system, which includes the air compressor, filtration, nitrogen generator, and buffer tanks, delivered and installed as a complete package.
- B. Technology: The system shall use Pressure Swing Adsorption (PSA) or membrane technology to produce nitrogen gas from a compressed air supply. The specific technology must be chosen based on the application's required flow, pressure, and purity.
- C. Purity: The nitrogen generator shall be capable of producing nitrogen with a purity of Specify required purity, e.g., 95% to 99.999%.
 1. Flow Rate: The system shall provide a continuous nitrogen flow rate of [Specify standard cubic feet per hour (SCFH), normal cubic meters per hour (Nm³/hr), or gallons per minute (GPM)] at the required purity.
- A. Discharge Pressure: The generator shall deliver nitrogen at a consistent pressure of 150 psi to the point of use.
- B. Dew Point: The generated nitrogen shall have a dew point of [Specify dew point, e.g., -40°C or lower].
- C. Operating Conditions: The system must operate within the specified ambient temperature range, typically 40°F to 105°F (5°C to 40°C).
- D. Product Data: Submit manufacturer's product data sheets, including technical specifications, dimensions, power requirements, and maintenance schedules.
 1. B. Drawings: Provide system layout drawings showing all major components, piping connections, and required clearances.
 2. C. Test Reports: Furnish certified factory test results confirming the system meets specified purity, flow, and pressure requirements.
 3. D. Warranty: The manufacturer shall provide a detailed warranty outlining coverage for all system components.
- E. Quality assurance
 1. A. Manufacturer: The system shall be sourced from a manufacturer with a proven track record of producing reliable and high-performance nitrogen generation systems.
 2. B. Certifications: The system must comply with all relevant industry standards and safety regulations (e.g., ISO, UL, or FM approved for fire protection applications).
- F. Part 2: Products
- G. Nitrogen generator system

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1. Technology: The system shall be either a PSA or membrane-type generator, based on the application's specific purity and flow rate needs.
- H. PSA: For high-purity applications, the system shall include twin adsorption vessels filled with carbon molecular sieve (CMS).
- I. Membrane: For lower-purity applications, the system shall utilize a bundle of semi-permeable hollow-fiber membranes.
 1. Enclosure: The generator shall be contained within a durable, powder-coated steel cabinet suitable for the operating environment.
 2. C. Instrumentation: The system shall include all necessary instrumentation for monitoring, including pressure gauges for inlet air and outlet nitrogen, and a purity analyzer with digital readout.
- J. Ancillary equipment
- K. Air Compressor: The system can be supplied with or without an integral or separate air compressor. The compressor must provide compressed air at the specified pressure and flow rate to meet system demands.
- L. Filtration and Drying: An air pretreatment system is required to ensure the compressed air meets the generator's inlet air quality requirements (e.g., ISO 8573-1). This system must include:
 - M. Coalescing pre-filters: To remove particulates, bulk liquids, and oil vapor.
 - N. Refrigerated or Desiccant Air Dryer: To reduce the air's moisture content.
- O. Storage Tanks:
 1. Air Receiver Tank: For the compressed air supply to the generator.
- P. Nitrogen Buffer Tank: To store the produced nitrogen and balance output.
- Q. Location:
 1. The generator and all associated equipment shall be installed in a well-ventilated area with adequate clearance for maintenance and service.
 2. B. Piping: Connect all compressed air and nitrogen piping as shown in the approved drawings. Piping materials shall be suitable for the specified pressures and gas type.
- R. Electrical Connections: All electrical connections shall be performed by a qualified electrician in accordance with local and national electrical codes.
- S. Commissioning
 1. Startup: The manufacturer's service representative shall perform the initial startup and verification of the system.
 2. Testing: Test the system to demonstrate it produces the specified nitrogen purity and flow rate under normal operating conditions.
- T. Training: The manufacturer's representative shall provide on-site training to the owner's personnel on system operation, monitoring, and basic maintenance.
- U. Warranty
 1. Coverage: The contractor shall facilitate the manufacturer's warranty registration process and provide the owner with all warranty documents.
- V. Maintenance

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1. Schedule: Provide the owner with a detailed maintenance schedule, including all necessary service intervals for filter replacements and other upkeep.
2. Manual: A comprehensive operation and maintenance manual shall be delivered with the system.

2.09 VACUUM PUMPS

- A. Performance Requirements
 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NFPA 99, "Health Care Facilities Code," for vacuum equipment and accessories for medical and dental vacuum systems.
 3. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.
 4. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vacuum equipment mounting.
- B. General Requirements For Vacuum Systems
 1. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.
 2. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 - a. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 - b. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 - c. Control Voltage: 120 V ac or less, using integral control power transformer.
 - d. Motor Overload Protection: Overload relay in each phase.
 - e. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 - f. Automatic control switches to alternate lead-lag vacuum pumps for duplex and sequence lead-lag vacuum pumps for three or more vacuum pumps.
 - g. Instrumentation: Include vacuum pump inlet and receiver vacuum gauges, hour meter, vacuum pump discharge-air and coolant temperature gauges, and control transformer.
 - h. Alarm Signal Devices: For connection to alarm system to indicate when backup vacuum pump is operating.
 - i. Provide 65k AIC SCCR rating.
 3. Receivers: Steel tank constructed in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.
 - a. Interior Finish: Corrosion-resistant coating.
 - b. Accessories: Include vacuum relief valve, vacuum gauge, and drain.
- C. Vacuum Pump Packaged System - Rotary Claw, Dry

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install products and equipment in accordance with manufacturer's instructions.
- B. Pipe, Tube, and Fittings:

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1. Install piping parallel and perpendicular to walls. Install without springing or forcing.
 2. Provide pipe sleeves where pipes and tubing pass through walls, floors, roofs, and partitions. Extend 2 inches (50 mm) above finished floors. See Section 220517.
 3. Make changes in size with reducing fittings.
 4. Make changes in direction or required turns or offsets with fittings.
 5. Cut pipe and tubing accurately and squarely.
 6. Ream pipe and tube ends. Remove burrs.
 7. Remove scale and dirt from outside of piping before assembly.
- C. Pipe Hangers and Supports:
1. See Section 220529. Install in accordance with MSS SP-58.
 2. Medical Gases: Space hangers and support vertical piping in accordance with NFPA 99.
- D. Piping Identification:
1. Identify piping with tape and decals. See Section 220553.
 2. Install labeling on pipe at intervals of not more than 20 feet (6 m) and at least once in each room and each story traversed by pipeline.
 3. Medical Gas Systems: Label and color code piping in accordance with NFPA 99.
- E. Valves:
1. Except where indicated or in flush wall mounted cabinets, install manual shut off valves with stem vertical and accessible for operation and maintenance.
- F. Installation Of Compressed-Air Equipment
1. General Requirements for Compressed-Air Equipment Installation:
 - a. Install isolation valves at connections to equipment. Isolate systems including receivers, dryers, and filters until after completion and approval of purity tests for compressed air system. Tie-in at flange or union joint.
 - b. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
 - c. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
 - d. Install 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.
 - e. Install equipment to allow right of way for piping installed at required slope.
 - f. Install the following devices on compressed-air equipment:
 - 1) Thermometer, Pressure Gauge, and Safety Valve: Install on each compressed-air receiver.
 - 2) Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
 - 3) Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.
 2. Laboratory Compressed-Air Equipment Installation:
 - a. Install compressed-air equipment, except wall-mounted equipment and diaphragm air compressors, on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 03 - Cast-in-Place Concrete.

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- b. Comply with requirements for vibration isolation devices specified in Section 220548 - Vibration and Seismic Controls for Plumbing Piping and Equipment
 - c. Install diaphragm air compressors on -MAKE A SELECTION-.
 - 1) Anchor air compressors to surface in accordance with manufacturer's written instructions and seismic criteria applicable to Project.
- G. Equipment Piping Connections
 - 1. Comply with requirements for piping specified in this section and in Section 221005 - Plumbing Piping.
 - 2. Where installing piping adjacent to equipment, allow space for service and maintenance.
 - 3. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.
 - 4. Connect water supply to compressed-air equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221006 - Plumbing Piping Specialties.
- H. Equipment Electrical Connections
 - 1. Connect wiring in accordance with Division 26 - Low-Voltage Electrical Power Conductors and Cables.
 - 2. Ground equipment in accordance with Division 26 - Grounding and Bonding for Electrical Systems.
 - 3. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
 - 4. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - a. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 26
 - b. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.
- I. Equipment Control Connections
 - 1. Install control and electrical power wiring to field-mounted control devices.
 - 2. Connect control wiring in accordance with Division 26 - Control-Voltage Electrical Power Cables.

3.02 IDENTIFICATION

- A. Identify laboratory compressed-air equipment system components. Comply with requirements for identification specified in 220553 - Identification for Plumbing Piping and Equipment.
- B. Identify medical compressed-air equipment system components. Comply with requirements for identification specified in NFPA 99.

3.03 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that air compressor inlet filters and piping are clear.

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5. Check for equipment vibration-control supports and flexible pipe connectors, and verify that equipment is properly attached to substrate.
6. Check safety valves for correct settings. Ensure that settings are higher than air compressor discharge pressure, but not higher than rating of system components.
7. Drain receiver tank(s).
8. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
9. Test and adjust controls and safeties.

- B. Prepare written report documenting testing procedures and results.

3.04 ADJUSTING

- A. Adjust equipment to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust control set points.

3.05 FIELD QUALITY CONTROL

- A. See Division 01 - Quality Requirements for additional requirements.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Tests and Inspections:
1. Medical Compressed-Air Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air equipment concurrently with tests, inspections, and certification of the following if applicable: medical vacuum equipment, medical vacuum piping, medical compressed-air piping, and medical gas piping.
 2. Preparation: Perform medical compressed-air equipment tests in accordance with requirements in NFPA 99 for the following:
 - a. Air-quality purity test.
 - b. System operation test.
 3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030, and NFPA 99 for verification of medical compressed-air equipment.
 4. Replace damaged and malfunctioning controls and equipment.
 5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - a. Inspections performed.
 - b. Procedures, materials, and gases used.
 - c. Test methods used.
 - d. Results of tests.
 6. Components will be considered defective if they do not pass tests and inspections and is to be replaced with new components.
- D. Prepare test and inspection reports.

3.06 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors and associated accessories.

END OF SECTION 226000

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SECTION 230500
COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. General Requirements
 - 3. Escutcheons.
 - 4. Grout.
 - 5. Equipment installation requirements common to equipment sections.
 - 6. Concrete bases.
 - 7. Supports and anchorages.

1.3 DEFINITIONS

- A Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct 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 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 The following are industry abbreviations for rubber materials:

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1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 GENERAL SUBMITTAL REQUIREMENTS

- A Identify each submittal in detail. Note what differences, if any, exist between the submitted item and the specified item. Failure to identify the differences will be considered cause for disapproval. If differences are not identified and are not discovered during the submittal review process, the Contractor remains responsible for providing equipment and materials that meet the Specifications and Drawings.
- B Submittals processed by the Architect/Engineer do not become Contract Documents.
- C The purpose of submittals is to establish a reporting procedure for the Architect/Engineer to monitor the Contractor's compliance with the Contract Documents.
- D If deviations, discrepancies, or conflicts between submittals and the Contract Documents are discovered (before or after processing by the Architect/Engineer), the Contract Documents shall control.
- E Shop drawings of the following HVAC equipment and materials shall be submitted:
 1. Pipe, fittings, and joining methods for the various systems.
 2. Pipe hangers and saddles.
 3. Valves.
 4. Expansion joints and guides.
 5. Flexible connectors.
 6. Gauges.
 7. Vibration isolators.
 8. Pipe insulation.
 9. Equipment insulation.
 10. Ductwork insulation.
 11. Expansion tanks.
 12. Energy meters.
 13. Pumps.
 14. Glycol system components.
 15. Boilers.
 16. Prefabricated stacks and flues.
 17. Heat exchangers.
 18. Chillers.
 19. Fan coil units.
 20. Unit heaters.
 21. Custom air handling units.
 22. Fans.
 23. Air filters.
 24. Filter banks.

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25. Dampers.
26. VAV terminal units.
27. Supply and exhaust air valves.
28. Air outlets and inlets.
29. Variable frequency drives.
30. Automatic temperature controls.
31. Finned tube radiation
32. Side stream filters.

1.5 REFERENCES AND STANDARDS:

- A The editions recognized by latest Ohio Building Code of the following are hereby included in and made a part of Division 23:
1. NFPA National Fire Protection Association
 2. UL Underwriters' Laboratories, Inc.
 3. AFI Air Filter Institute
 4. NEMA National Electrical Manufacturer's Association
 5. NEC National Electric Code
 6. ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers
 7. ARI American Refrigeration Institute
 8. AMCA Air Moving and Conditioning Association
 9. ASME American Society of Mechanical Engineers
 10. AWS American Welding Society
 11. ANSI American National Standards Institute
 12. AGA American Gas Association
 13. SMACNA Sheet Metal and Air Conditioning Contractors National Association
 14. HI Hydronics Institute
 15. OSHA Occupational Safety and Health Act

1.6 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 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.

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1.7 DELIVERY, STORAGE, AND HANDLING

- A Piping, duct, equipment, and associated accessories kept on-site should be stored off the ground on skids, ends should be capped or sealed, and these items should be covered with plastic to prevent fouling or contact with excessive moisture. Piping, duct, and equipment should be cleaned of debris inside and out before installation and should be kept clean and protected throughout construction.
- B Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 COORDINATION

- A Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC 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 HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- D Install additional distribution offsets as required to obtain maximum headroom or to avoid conflicts with other work, without additional cost to the Owner.
- E The contractor shall produce full coordination drawings between all trades identifying any areas of interference or clashes prior to the start of construction. Modifications shall be made to the associated systems to resolve the issue in coordination with and approval of the architect and engineer.
- F It is required that Contractors visit the site of the work and become familiar with the conditions affecting the installation prior to bidding. Submission of a Bid shall presuppose knowledge of such conditions and no additional compensation shall be allowed where extra labor or materials are required because of the lack of knowledge of these conditions.

1.9 DESIGN DRAWINGS

- A The Contract Drawings are diagrammatic and are not intended to show exact location of equipment, piping and ductwork unless dimensions are given. Systems and distribution are to be installed along the general plans shown on the Drawings, but in coordination with actual field conditions.

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- B Extra costs which might result from deviations from the Drawings, so as to avoid interferences, shall be considered a "Job Condition", and no additional compensation will be considered applicable. In the event that such interferences occur in the course of the Work, due to an error, omission, or oversight by the Contractor, no additional compensation shall be allowed. Interferences which may occur during the course of construction shall be brought to the immediate attention of the Architect, and his/her decision, confirmed in writing, shall be final.

1.10 EQUIPMENT START-UP

- A Start-up of all mechanical equipment shall be video-recorded by the contractor. A digital copy shall be turned over to the Owner's maintenance staff.

PART 2 PRODUCTS

2.1 EQUIPMENT AND MATERIALS:

- A All equipment and materials shall be furnished in strict accordance with the equipment named and according to Specification requirements. Each bid shall be based upon one of the materials or manufacturers specified.
- B Equipment and materials specified shall be considered to have prior approval, but submittal for approval is required. Furnish construction drawings to other Contractors when required to coordinate construction.
- C Where multiple manufacturers are named the drawings and specifications are based on the requirements and layouts for the equipment of the first named manufacturer. Any change required by the use of other named manufacturers such as revisions to foundations, bases, piping, controls, wiring, openings, and appurtenances shall be made by the Contractor at no additional cost to the Owner.

2.2 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, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- D One-Piece, Cast-Brass Type: With set screw and polished chrome-plated finish

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- E Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
- F One-Piece, Floor-Plate Type: Cast-iron floor plate.
- G Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.3 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 3 EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A Install piping according to the following requirements and Division 23 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 Piping shall not project beyond walls or steel lines nor shall it hang below slabs more than is absolutely necessary. Particular attention shall be paid to the required clearances.
- F Offset piping where required to avoid interference with other work, to provide greater headroom or clearance, or to conceal pipe more readily. Offsets shall be properly drained or trapped where necessary.

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- G Provide swing joints and expansion bends wherever required to allow the piping to expand without undue stress to connections or equipment.
- H Exposed piping around fixtures or in other conspicuous places shall not show tool marks at fittings.
- I Isolate pipe from the building construction to prevent transmission of vibration to the structure and to eliminate noise.
- J Install piping such that any equipment connected to piping may be removed by disconnecting two (2) flanges or unions and removing only one or two pipe sections. All equipment shall have bolted or screwed flanges or unions at pipe connections.
- K Install fittings for changes in direction and branch connections. T-drill system for mechanically formed tee connections and couplings, and Victaulic hole cut piping system are not allowed.
- L Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.
- M Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- N Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- O Install piping to permit valve servicing.
- P Install piping at indicated slopes.
- Q Install piping free of sags and bends.
- R Install piping to allow application of insulation.
- S Cap and plug all openings in pipes during construction with suitable metal plugs or cap to keep out dirt and rubbish until equipment is connected.
- T Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- U Select system components with pressure rating equal to or greater than system operating pressure.

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- V Install escutcheons for penetrations of walls, ceilings, and floors
- W All pipes extending through the roof shall be flashed per Architectural details.
- X Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- Y Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- Z 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 annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- AA 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.
- BB Verify final equipment locations for roughing-in.
- CC Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

- A Join pipe and fittings according to the following requirements and Division 23 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.

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- F Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- G Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 5. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- I Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- J Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
- K PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.
 - 3. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.3 PIPING CONNECTIONS

- A Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
- B Installation of dielectric fittings
 - 1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- C Unions shall be used in preference to couplings where their use will facilitate dismantling the pipe for maintenance.

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- D Pipe sizes indicated shall be carried full size to equipment served. Any change of size to match equipment connection shall be made within one foot of the equipment. At temperature control valves with sizes smaller than connected lines, reduction shall be made immediately adjacent to valves.

3.4 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 HVAC 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.

3.5 CONCRETE BASES

- A Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit. Install dowel rods to connect concrete base to concrete floor.
 - 2. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete"

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A Refer to Division 05 Section "Metal Fabrications" for structural steel.

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- B Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C Field Welding: Comply with AWS D1.1.

3.7 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC 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.

3.8 GROUTING

- A Mix and install grout for HVAC 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 230500

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SECTION 230516
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Flexible pipe connectors.
- B Expansion joints and compensators.
- C Pipe loops, offsets, and swing joints.

1.2 RELATED REQUIREMENTS

1.3 REFERENCE STANDARDS

- A ASTM A536 - Standard Specification for Ductile Iron Castings; 1984, with Editorial Revision (2019).

1.4 SUBMITTALS

- A Product Data:
 - 1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot (meter) and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
 - 2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

- A Flex-Weld, Inc
- B Mercer Rubber Company
- C The Metraflex Company

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2.2 FLEXIBLE PIPE CONNECTORS

- A Inner Hose: Stainless Steel.
- B Exterior Sleeve: Double braided, stainless steel.
- C Pressure Rating: 125 psi up to 12 inch (862 kPa up to 300 mm, DN).
- D Maximum Service Temperature: 450 degrees F (232 degrees C).
- E End Connections: Flanged.
- F Size: Use pipe sized units.
- G Maximum offset: 3/4 inch (20 mm) on each side of installed center line.

2.3 EXPANSION JOINTS - METAL BELLOWS TYPE

- A Provide with tie rods to prevent over-compression or over-elongation.
- B Pressure Rating: 125 psi and 400 degrees F (862 kPa and 204 degrees C).
- C Maximum Compression: 1-3/4 inches (45 mm).
- D Maximum Extension: 1/4 inch (6 mm).
- E End Connections: Flanged.
- F Size: Use pipe sized units.

2.4 EXPANSION JOINTS - HOSE AND BRAID

- A Provide flexible loops with two flexible sections of hose and braid, two 90 degree elbows, and 180 degree return with support brackets and plugged drain port for steam service.
- B Maximum Allowable Motion: 2 inch (50.8 mm) in the x, y, and z planes with no thrust loads to the building structure
- C Maximum Working Pressure: 150 psi (1030 kPa) at 800 degrees F (426.7 degrees C).

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- D Construction: Class 150, schedule 40, stainless steel hose and braid assembly with carbon steel fittings, including elbows and flanged end connections sized to match pipe segment
 - 1. Selected Product to Accommodate:
 - a. Compression and Expansion Axial Deflection: .
 - b. Angular Rotation: 15 degrees.
 - c. Force developed by 1.5 times specified maximum allowable operating pressure.
 - 2. Provide necessary accessories including, but not limited to, swivel joints.

2.5 ACCESSORIES

- A Pipe Alignment Guides:
 - 1. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch (25 mm) thick insulation, minimum 3 inches (75 mm) travel.
- B Engineered Riser Anchor Clamps:
 - 1. Applications:
 - a. Provide one clamp above and one clamp below the slab to anchor pipe.
 - 2. Provide two piece, ductile iron in compliance with ASTM A536. Use with metal pipes with an outer diameter of 2.5 inches (64 mm) to 8 inches (203 mm).

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install flexible pipe connectors on pipes connected to vibration isolated equipment. Provide line size flexible connectors.
- C Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- D Anchor pipe to building structure where indicated. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9.
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-58, Type 24; U bolts bolted to anchor.

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SECTION 230517
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 RELATED REQUIREMENTS

- A Section 230719 - HVAC Piping and Equipment Insulation.

1.3 REFERENCE STANDARDS

- A ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2022a.
- B ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2023a.

1.4 SUBMITTALS

- A 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.

1.5 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.

PART 2 PRODUCTS

2.1 PIPE SLEEVES

- A Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron, with plain ends.

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- B Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, hot-dip galvanized, with plain ends.
- C Sheet Metal Sleeves: ASTM A653/A653M, 24 gauge minimum thickness; hot-dip galvanized, round tube closed with welded longitudinal joint.
- D Vertical Piping:
 - 1. Sleeve Length: 2 inch (50 mm) above finished floor.
 - 2. Provide sealant for watertight joint.
- E Sleeves for pipe passing through interior walls, partitions, and floors shall be sheet metal unless steel or cast iron sleeves are specified below.
- F Pipe Passing Through Above Grade Exterior Walls:
 - 1. Less than NPS 6: Steel pipe sleeves.
 - 2. NPS 6 and above: Cast-iron pipe sleeves.
 - 3. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
- G Pipes passing through above grade floor slabs and masonry walls shall have the space between the pipe or insulation and the sleeve packed with non-asbestos wicking or other suitable, approved, non-combustible material.
- H Pipe Passing Through Concrete Beam Flanges:
 - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 - 2. Connect sleeve with floor plate except in mechanical rooms.
 - 3. Flush with the side of the beam and large enough to accommodate bare pipe only.
- I Clearances:
 - 1. Provide allowance for insulated piping.
 - 2. Wall, Floor, Partitions, and Beam Flanges: minimum 1 inch (25 mm) greater than external pipe diameter.
 - 3. For installation of pipe-sleeve seals: 1 inch (25 mm) greater than external pipe diameter.
 - 4. All Rated Openings and walls of Mechanical Equipment Rooms: Caulked tight with fire stopping material in compliance with ASTM E814 to prevent the spread of fire, smoke, and gases.

2.2 PIPE-SLEEVE SEALS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Link-Seal.
 - 2. Metraflex Co.

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3. Fernco.

B Modular Mechanical Sleeve-Seal:

1. EDPM-rubber 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. Carbon steel pressure end plates. Include two for each sealing element.
5. 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.

C Pipe Sleeve Material:

1. Bearing Walls: Steel, cast iron, or terra-cotta pipe.
2. Masonry Structures: Sheet metal or fiber.

PART 3 EXECUTION

3.1 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.

3.2 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 Structural Considerations:
1. Do not penetrate building structural members unless indicated.
- E Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
1. Underground Piping: Caulk pipe sleeve watertight. Provide mechanical sleeve-seal system.
 2. Aboveground Piping:
 - a. Pack solid using mineral fiber in compliance with ASTM C592.

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- b. Fill space with an elastomer caulk to a depth of 0.50 inch (15 mm) where penetrations occur between conditioned and unconditioned spaces.
 - 3. 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.
 - 4. Caulk exterior wall sleeves watertight. Provide mechanical sleeve-seal system.
- F 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.
- G 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.

END OF SECTION 230517

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SECTION 230519
METERS AND GAUGES FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Electromagnetic flow meters.
- B Pressure gauges and pressure gauge taps.
- C Thermometers and thermometer wells.

1.2 REFERENCE STANDARDS

- A ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).
- B ASME B40.100 - Pressure Gauges and Gauge Attachments; 2022.
- C ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014 (Reapproved 2020).
- D ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014 (Reapproved 2021).
- E NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- F UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.

1.3 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.

PART 2 PRODUCTS

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2.1 ELECTROMAGNETIC FLOW METERS

- A Manufacturers:
 - 1. Badger Meter, Inc
 - 2. Foxboro, a brand of Schneider Electric
 - 3. Onicon, Inc
- B Liquid Flow Capacity Range: As indicated on drawings.
- C Construction: Stainless steel or aluminum sensor with integral NEMA EN 10250 Type 4 or 4X stainless steel or aluminum enclosure to hold thermal mass sensor and circuits with numeric display for consumption reading.
- D Liquid Conductivity: 5 mS/cm, minimum.
- E Accuracy: 0.02 percent of value applied to manufacturer-specified velocity range.
- F Output: Two-wire, 0 to 10 VDC, non-loop powered.
- G BAS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet MS/TP.
- H Service Pressure and Temperature: Up to 400 psi (27.6 bar) and 15 to 250 degrees F (minus 9.4 to 125.6 degrees C) liquid side, 150 degrees F (65.5 degrees C) ambient.

2.2 PRESSURE GAUGES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Ashcroft Inc.
 - 2. Dwyer Instruments, Inc
 - 3. Omega Engineering, Inc
 - 4. Trerice, H. O. Co.
 - 5. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - 6. Weiss Instruments, Inc.
- 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 (115 mm) diameter.
 - 3. Mid-Scale Accuracy: One percent.
 - 4. Scale: Psi.

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2.3 PRESSURE GAUGE TAPPINGS

- A Gauge Cock: Tee or lever handle, brass for maximum 150 psi (1034 kPa).
- B Needle Valve: Brass, 1/4 inch (6 mm) NPT for minimum 150 psi (1034 kPa).
- C Pulsation Damper: Pressure snubber, brass with 1/4 inch (6 mm) connections.
- D Syphon: Steel, Schedule 40, 1/4 inch (6 mm) angle or straight pattern.

2.4 STEM TYPE THERMOMETERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal:
 - 1. Dwyer Instruments, Inc
 - 2. Trerice, H. O. Co.
 - 3. Weiss Instrumentents, Inc.
 - 4. Winters Instruments
- 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 (225 mm) scale.
 - 2. Window: Clear glass.
 - 3. Stem: 1-1/4 inch (20 mm) NPT brass.
 - 4. Accuracy: 2 percent, per ASTM E77.
 - 5. Calibration: Degrees F.

2.5 THERMOWELLS

- A Thermowells
 - 1. Standard: ASME B40.200.
 - 2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
 - 3. Material for Use with Copper Tubing: CNR or CUNI.
 - 4. Material for Use with Steel Piping: CRES.
 - 5. Type: Stepped shank unless straight or tapered shank is indicated.
 - 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
 - 7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
 - 8. Bore: Diameter required to match thermometer bulb or stem.
 - 9. Insertion Length: Length required to match thermometer bulb or stem.
 - 10. Lagging Extension: Include on thermowells for insulated piping and tubing.

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11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B Heat-Transfer Medium: Mixture of graphite and glycerin.

2.6 TEST PLUGS

A Manufacturers:

1. Dwyer Instruments, Inc
2. Watts Water Technologies, Inc
3. Weiss Instruments, LLC
4. Weksler Glass Thermometer Corp

B Test Plug: 1/4 inch (6 mm) or 1/2 inch (13 mm) brass fitting and cap for receiving 1/8 inch (3 mm) outside diameter pressure or temperature probe with Nordel core for temperatures up to 350 degrees F (176 degrees C).

PART 3 EXECUTION

3.1 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.
- C Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch (60 mm) for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- D Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.
- E Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- F Install thermowells with extension on insulated piping.
- G Fill thermowells with heat-transfer medium.

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- H Provide instruments with scale ranges selected according to service with largest appropriate scale.
- I Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- J Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- K Locate test plugs adjacent thermometers and thermometer sockets.

3.2 SCHEDULE

- A Pressure Gauges and Location:
 - 1. Pumps 0 to 100 psi.
 - 2. Expansion tanks 0 to 100 psi.
- B Pressure Gauge Locations:
 - 1. Control valves 3/4 inch (20 mm) & larger - inlets and outlets.
 - 2. Major coils - inlets and outlets.
 - 3. Pump - suction and discharge.
 - 4. Heat exchanger - inlets and outlets.
 - 5. Chiller - inlets and outlets.
 - 6. Boiler - inlets and outlets.
 - 7. Where indicated on Drawings or Control Diagrams.
- C Thermometer Locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Air-handling unit coil - inlets and outlets.
 - 3. Chiller - inlets and outlets.
 - 4. Boiler - inlets and outlets.
 - 5. Where indicated on Drawings or Control Diagrams.
- D Stem Type Thermometers and Location:
 - 1. Headers to central equipment.
 - 2. Coil banks - inlets and outlets.
 - 3. Heat exchangers - inlets and outlets.
 - 4. Heating Hot-Water.
 - 5. Chilled-Water.
- E Test Plug Locations:
 - 1. Control valves 1 inch (25 mm) & larger - inlets and outlets.
 - 2. Reheat coils - inlets and outlets.

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3. All locations with thermometers.
4. Where indicated on Drawings or Control Diagrams.
5. Cabinet heaters - inlets and outlets.
6. Unit heaters - inlets and outlets.
7. Fan coil unit - inlets and outlets.

END OF SECTION 230519

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SECTION 230523
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 RELATED REQUIREMENTS

- A Division 23 HVAC Piping Sections for specialty valves applicable to those Sections only.
- B Section 230553 - Identification for HVAC Piping and Equipment.

1.3 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.

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I WOG: Water, oil, and gas.

1.4 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; 2020.
- D ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves; 2022, with Errata (2023).
- 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; 2020.
- H ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2023).
- I ASTM A536 - Standard Specification for Ductile Iron Castings; 1984, with Editorial Revision (2019).
- J ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings; 2017.
- K AWWA C606 - Grooved and Shouldered Joints; 2022.
- L MSS SP-45 - Drain and Bypass Connections; 2020.
- M MSS SP-67 - Butterfly Valves; 2022.
- N MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends; 2018.
- 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 .

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1.5 SUBMITTALS

- A Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
 - 1. Grooved end valves shall be specifically identified with the applicable style or series number.

1.6 QUALITY ASSURANCE

- A Manufacturer:
 - 1. Obtain valves for each valve type from single manufacturer.
 - 2. To assure uniformity and compatibility, all grooved end valves and adjoining couplings shall be the products of a single manufacturer.

1.7 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. Secure check valves in either the closed position or open position.
 - 5. 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. 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

2.1 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. Isolation (Shutoff): Butterfly, Ball, and Plug.
 - 2. Swing Check (Pump Outlet):

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- a. Size 2 inch (50 mm, DN) and Smaller: Bronze with bronze disc.
 - b. Size 2-1/2 inch (65 mm, DN) and Larger: Iron with lever and weight, lever and spring, or center-guided with resilient seat.
 - 3. Dead-End: Butterfly, single-flange (lug) type.
- C Required Valve End Connections for Non-Wafer Types:
- 1. Steel Pipe:
 - a. Size 2 inch (50 mm, DN) and Smaller: Threaded ends.
 - b. Size 2-1/2 inch (65 mm, DN) and Larger: Flanged ends.
 - 2. Copper Tube:
 - a. Size 2 inch (50 mm, DN) and Smaller: Threaded or press ends.
- D Heating Hot Water and Chilled Water Valves:
- 1. Size 2 inch (50 mm, DN) and Smaller, Bronze Valves:
 - a. Ball: Full port, two piece, bronze or brass trim.
 - b. Swing Check: Bronze disc, Class 125.
 - 2. Size 2-1/2 inch (65 mm, DN) and Larger, Iron Valves:
 - a. 2-1/2 inch (65 mm, DN) to 4 inch (100 mm, DN): May be provided with Threaded ends.
 - b. Single-Flange Butterfly: 2-1/2 inch (65 mm, DN) to 12 inch (300 mm, DN), ductile iron disc, EPDM seat, 200 CWP.
 - c. Grooved-End Butterfly: 2-1/2 inch (65 mm, DN) to 12 inch (300 mm, DN), 200 CWP.
 - d. Swing Check with Closure Control: 2-1/2 inch (65 mm, DN) to 12 inch (300 mm, DN), lever and spring, Class 125.
 - e. Grooved-End Check: 3 inch (80 mm, DN) to 12 inch (300 mm, DN), 300 CWP.

2.2 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. Gear Actuator: Quarter-turn valves 8 inch (200 mm, DN) and larger.
 - 2. Handwheel: Valves other than quarter-turn types.
 - 3. Hand Lever: Quarter-turn valves 6 inch (150 mm, DN) and smaller.
 - 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 (50 mm, DN) stem extensions and the following features:

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1. 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.
2. Butterfly Valves: Extended neck.

E 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. Solder Joint Connections: ASME B16.18.
4. Grooved End Connections: AWWA C606.

F 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.

G Bronze Valves:

1. Fabricate from dezincification resistant material.
2. Copper alloys containing more than 15 percent zinc are not permitted.

H Valve Bypass and Drain Connections: MSS SP-45.

I Manufacturers:

1. Apollo.
2. Crane Co.; Crane Valve Group; Crane Valves.
3. Hammond Valve.
4. Milwaukee Valve Company.
5. NIBCO Inc.
6. Victaulic.

2.3 BRONZE, BALL VALVES

A Two Piece, Full Port with Bronze or Brass Trim:

1. Comply with MSS SP-110.
2. WSP Rating: 150 psi (1,035 kPa).
3. WOG Rating: 400 psi (2,758 kPa).
4. Body: Forged bronze or dezincified-brass alloy.
5. End Connections: Pipe press or thread.
6. Seats: PTFE.
7. Stem: Bronze or brass.
8. Ball: Chrome plated brass.

2.4 IRON, SINGLE FLANGE BUTTERFLY VALVES

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- A Lug Style; Bidirectional Dead-End Service without Use of Downstream Flange:
 - 1. Comply with MSS SP-67, Type I.
 - 2. Lug Style, CWP Ratings:
 - a. Sizes 2 to 12 inch (50 to 300 mm, DN): 200 psi (1380 kPa).
 - b. Vacuum Service: Down to 29.9 in-Hg (101.2 kPa).
 - 3. Body Material: ASTM A126 cast iron or ASTM A536 ductile iron.
 - 4. Stem: One or two-piece stainless steel.
 - 5. Seat: EPDM.
 - 6. Disc: Nickel-plated ductile iron.

2.5 IRON, GROOVED-END BUTTERFLY VALVES

- A CWP Rating: 300 psi (2070 kPa).
 - 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.

2.6 BRONZE, SWING CHECK VALVES

- A Class 125:
 - 1. Pressure and Temperature Rating: MSS SP-80, Type 3.
 - 2. Design: Y-pattern, horizontal or vertical flow.
 - 3. WSP Rating: 200 psi (1,380 kPa).
 - 4. Body: Bronze, ASTM B62.
 - 5. End Connections: Threaded.
 - 6. Disc: Bronze.

2.7 IRON, SWING CHECK VALVES WITH CLOSURE CONTROL

- A Class 125:
 - 1. Comply with MSS SP-71, Type I.
 - 2. Sizes 2-1/2 to 12 inch (65 to 300 mm, DN): CWP Rating; 200 psi (1,380 kPa).
 - 3. Body Design: Clear or full waterway.
 - 4. Body Material: ASTM A126, gray iron with bolted bonnet.
 - 5. Ends: Flanged.
 - 6. Trim: Bronze.
 - 7. Gasket: Asbestos free.
 - 8. Closer Control: Factory installed, exterior lever, and spring or weight.

2.8 IRON, CENTER-GUIDED CHECK VALVES

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2.9 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 and butterfly 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

3.1 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.

3.2 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 valves in horizontal piping with stem at or above center of pipe.
- D Install check valves where necessary to maintain direction of flow as follows:
 - 1. Swing Check: Install horizontal maintaining hinge pin level.
- E Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- F Install valves in position that does not project into aisles or block access to other equipment.

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- G Provide chainwheels on operators for valves 4 NPS (100 DN) and larger where located 96 inches (2.4 m) or more above finished floor, terminating 60 inches (1.5 m) above finished floor.

END OF SECTION 230523

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SECTION 230529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Support and attachment components.
- B Equipment Supports

1.2 RELATED REQUIREMENTS

- A Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.

1.3 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.
- B Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured

1.4 SUBMITTALS

- A 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.

1.5 DELIVERY, STORAGE, AND HANDLING

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

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PART 2 PRODUCTS

2.1 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 supported with safety factor in accordance with AISC Manual of Steel Construction, but not less than 2.0.
4. Material in contact with pipe shall be compatible with piping material so that neither shall have deteriorating action on the other. If materials such as copper, stainless steel or other materials are not compatible, provide nonmetallic separation between uninsulated piping and metal supports
5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B Prefabricated Trapeze-Framed Metal Strut Systems:

1. MFMA-4 compliant, pre-fabricated, MSS SP-58 type 59 continuous-slot metal strut channel with associated tracks, fittings, and related accessories.
2. Strut Channel or Bracket Material:
 - a. Indoor Dry Locations: Use zinc-plated steel or galvanized steel.
3. Accessories: Provide bracket covers, cable basket clips, cable tray clips, clamps, conduit clamps, fire-retarding brackets, j-hooks, protectors, and vibration dampeners.

C Strut Channels:

1. ASTM A653/A653M galvanized steel bracket with clamps for surface mounting of piping or plumbing equipment support.
2. Channel or Bracket Kits: Include rods, brackets, end-fixed fittings, covers, clips, and other related hardware required to complete sectional trapeze section for piping or other support.

D Hanger Rods:

1. Threaded zinc-plated steel unless otherwise indicated.
2. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch (13 mm) diameter.
 - b. Piping up to 1 inch (25 mm, DN): 1/4 inch (6 mm) diameter.
 - c. Piping larger than 1 inch (25 mm, DN): 3/8 inch (10 mm) diameter.

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- d. Trapeze Support for Multiple Pipes: 3/8 inch (10 mm) diameter.

E Cable Hanging System Kits:

- 1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation
 - b. Ductmate Industries, Inc
 - c. Gripple, Inc
- 2. Provide cable-wire in bulk or precut lengths with respective cable hangers as required to hold minimum weight of 120 lb (54.4 kg).
- 3. Accessories: Provide brackets, clip or c-clip hangers, covers, and y-hook hangers.

F 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 (50 degrees C):
 - 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 (50 to 230 degrees C):
 - a. Overhead Support: MSS SP-58 Type 1 or 3 through 12, with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.

G Pipe Stanchions:

- 1. Manufacturers:
 - a. Anvil International; H-Block: www.anvilintl.com/#sle.
- 2. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
- 3. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
- 4. For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.

H Equipment Supports

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

I Beam Clamps:

- 1. MSS SP-58 types 19 through 23, 25 or 27 through 30 based on required load.
- 2. Beam C-Clamp: MSS SP-58 type 23, malleable iron and steel with plain, stainless steel, and zinc finish.
 - a. Use of "C" clamps and beam clamps of "C" pattern and any modifications thereof are prohibited for all sizes 6" and greater.
 - b. "C" Clamps for sizes 4" and under must be ductile iron with locknut; FM approved.
 - c. "C" Clamps used for sizes 3" and 4" must also be installed with Beam Clamp Retaining Straps with a minimum of 1" of strap to be bent over the beam side of the flange opposite the side the beam clamp is mounted on.

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3. Small or Junior Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish. For inverted usage provide manufacturer listed size(s).
 4. Wide Mouth Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish.
 5. Centerload Beam Clamp with Extension Piece: MSS SP-58 type 30, malleable iron with plain finish.
 6. FM (AG) and UL (DIR) Approved Beam Clamp: MSS SP-58 type 19, plain finish,
 7. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
 8. 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.
- J 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. 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.
 4. Copper Tube Pipe Clamp: MSS SP-58 type 8, epoxy plated copper.
 5. UL (DIR) listed: Pipe sizes 1/2 to 8 inch (15 to 200 mm, DN).
- K U-Bolts:
1. MSS SP-58 Type 24, carbon steel u-bolt for pipe support or anchoring.
- L Strut Clamps:
1. Pipe Clamp: Two-piece rigid, universal, or outer diameter type, carbon steel with epoxy copper or zinc finish.
- M Insulation Clamps:
1. Two bolt-type clamps designed for installation under insulation.
 2. Material: Carbon steel with epoxy copper or zinc finish.
- N Pipe Hangers:
1. Split Ring Hangers:
 - a. Provide hinged split ring and yoke roller hanger with epoxy copper or plain finish.
 - b. Material: ASTM A47/A47M malleable iron or ASTM A36/A36M carbon steel.
 - c. Provide hanger rod and nuts of the same type and material for a given pipe run.
 - d. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
 2. Clevis Hangers, Adjustable:
- O 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.

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P 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 (321 mm).
 - d. Minimum Service Temperature: Minus 40 degrees F (Minus 40 degrees C).
 - e. Maximum Service Temperature: 178 degrees F (81 degrees C).
 - f. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.

Q Anchors and Fasteners:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
2. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
3. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
4. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
5. Hollow Masonry: Use toggle bolts.
6. Hollow Stud Walls: Use toggle bolts.
7. Steel: Use beam-ceiling clamps, beam clamps, machine bolts, or welded threaded studs.
8. Beam Ceiling Flanges: ASTM A47/A47M Grade 32510, malleable iron or stainless steel with copper, plain, stainless steel, or zinc finish.
9. Sheet Metal: Use sheet metal screws.
10. Wood: Use wood screws.
11. Powder-actuated 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. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

2.2 ROOF LEVEL SUPPORTS

A Pipe Supports: Pipe supports shall be one (1) of the following:

1. Support Without Pipe Rollers: Pate Style ES equipment supports (or equal) constructed of 18 gauge galvanized steel, unitized construction with integral base, continuous welded corner seams, pressure treated two (2) x four (4) wood nailer and counterflashing with galvanized screws. The overall height for each support shall be eighteen (18) inches from the finished roof to the top of the counterflashing plus the height of the pipe supports and the pipe. Contractor shall provide galvanized Unistrut type channel tracts, with galvanized washers, nuts, bolts, and pipe clamps to secure the pipe to the tract and the track to the equipment support.

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2. Support With Pipe Rollers: Pate Style PRS or MPRS equipment supports (or equal) constructed of heavy gage galvanized steel, unitized construction with integral base, continuous welded corner seams, pressure treated (2) x four (4) wood nailer and counterflashing with galvanized screws. Roller assembly shall include galvanized steel channel tracks, galvanized steel fittings, washers, nuts, bolts, and painted cast iron rollers. The overall height for each support shall be eighteen (18) inches from the finished roof to the top of the counterflashing plus the height of the pipe rack. Contractor shall provide galvanized insulation shields to protect the pipe insulation at each support point.
- B Pipe Curbs: Pipe curbs for pipes up to six (6) inches with or without insulation shall be as follows:
1. Pipe Curb Assembly: Pate Style PCC series (or equal) pipe curb assembly constructed of heavy gauge galvanized steel, unitized construction with integral base plate, one and one half (1-1/2) inch insulation, pressure treated two (2) inch x two (2) inch wood nailer. The overall height for each curb shall be eighteen (18) inches from the finished roof level to the top of the pipe cover. Assembly shall be furnished with an acrylic clad thermoplastic cover, galvanized fastening screws and graduated step boots with stainless steel clamps fit around the pipe risers passing through the curb assembly and cover.
- C Pipe Seal Assembly: For a single pipe application, shall be a one piece spun aluminum base with full five (5) inch sloped roof surface flange, graduated step PVC boot and adjustable stainless steel clamp.
- D Duct & Equipment Supports
1. Supports constructed of 18 gauge galvanized steel, unitized construction with integral base, continuous welded corner seams, pressure treated two (2) x four (4) wood nailer and counterflashing with galvanized screws. The overall height for each support shall be eighteen (18) inches from the finished roof to the top of the counterflashing plus the height of the pipe supports and the pipe. Contractor shall provide galvanized Unistrut type channel tracts, with galvanized washers, nuts, bolts, and pipe clamps to secure the pipe to the tract and the track to the equipment support.

PART 3 EXECUTION

3.1 INSTALLATION REQUIREMENTS

- 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 the A/E, do not provide support from suspended ceiling support system or ceiling grid.

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- D Unless specifically indicated or approved by the A/E, do not provide support from roof deck.
- E Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- F Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- G Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.
- H 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.
- I Piping Support and Attachment
 - 1. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
 - 2. Adjustable steel clevis hangers for individual horizontal piping less than 60 feet (18 m) long.
 - 3. Adjustable roller hangers for individual horizontal piping 60 feet (18 m) or longer.
 - 4. Install stainless-steel pipe hangers and attachments for piping in corrosive environments.
 - 5. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
 - 6. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping. Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
 - 7. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
 - 8. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - 9. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
- J Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.

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K Secure fasteners according to manufacturer's recommended torque settings.

L Remove temporary supports.

3.2 FIELD QUALITY CONTROL

A Inspect support and attachment components for damage and defects.

B Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

C Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

END OF SECTION 230529

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SECTION 230533
HEAT TRACING FOR HVAC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Self-regulating parallel resistance electric heating cable.

1.2 RELATED REQUIREMENTS

- A Section 230553 - Identification for HVAC Piping and Equipment.

1.3 REFERENCE STANDARDS

- A IEEE 515.1 - IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications; 2022.
- B NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 SUBMITTALS

- A See Section 013000 - Administrative Requirements, for submittal procedures.
- B Product Data: Provide data for electric heat tracing.
- C Shop Drawings: Indicate electric heat tracing layout, electrical terminations, thermostats, controls, and branch circuit connections.

1.5 WARRANTY

- A See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B Provide two year manufacturer warranty for cables, connection kits, accessories, and controls.

PART 2 PRODUCTS

2.1 SELF-REGULATING PARALLEL RESISTANCE ELECTRIC HEATING CABLE

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- A Manufacturers:
 - 1. Chromalox, Inc.
 - 2. Pentair.
 - 3. Thermon Manufacturing Compan.
- B Provide products listed, classified, and labeled by UL (DIR), ITS (DIR), or testing firm acceptable to authorities having jurisdiction (AHJ).
- C Factory Rating and Testing: Comply with IEEE 515.1.
- D Heating Element:
 - 1. Provide pair of parallel No. 16 tinned or nickel coated stranded copper bus wires embedded in cross linked conductive polymer core with varying heat output in response to temperature along its length.
 - 2. Terminations: Waterproof, factory assembled, non-heating leads with connector at one end and water-tight seal at opposite end.
 - 3. Capable of crossing over itself without overheating.
- E Insulated Jacket: Flame retardant polyolefin.
- F Cable Cover: Provide tinned copper and polyolefin outer jacket with UV inhibitor.
- G Maximum Power-On Operating Temperature: 150 degrees F (65 degrees C).
- H Maximum Power-Off Exposure Temperature: 185 degrees F (85 degrees C).

2.2 CONNECTION KITS

- A Provide power connection, splice/tee, and end seal kits compatible with the heating cable and without requiring cutting of the cable core to expose bus wires.
- B Furnish with NEMA 4X rating for prevention of corrosion and water ingress.
- C Provide UV stabilized components.

2.3 ACCESSORIES

- A Provide Accessories As Indicated or As Required for Complete Installation, Including but Not Limited To:
 - 1. Cable ties.
 - 2. Silicone end seals and splice kits.
 - 3. Installation clips.

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4. Warning labels for attachment to exterior of piping insulation. Refer to Section 230553.

2.4 CONTROLS

- A Pipe Mounted Thermostats:

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that piping and equipment are ready to receive work.
- B Verify field measurements are as indicated on shop drawings.
- C Verify required power is available, in proper location, and ready for use.

3.2 PREPARATION

- A Clean all surfaces prior to installation.
- B Prepare surfaces using the methods recommended by the manufacturer.

3.3 INSTALLATION

- A Install in accordance with manufacturer's recommendations.
- B Comply with installation requirements of IEEE 515.1 and NFPA 70, Article 427.
- C Apply heating cable linearly on pipe with fiberglass tape only after piping has successfully completed any required pressure testing.
- D Comply with all national and local code requirements.
- E Identification:
1. After thermal insulation installation, apply external pipeline decals to indicate presence of the thermal insulation cladding at intervals not to exceed 20 ft (6 m) including cladding over each valve or other equipment that may require maintenance.

3.4 FIELD QUALITY CONTROL

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A Perform start-up by factory technician or factory representative as per Owner's requirements.

B Field Testing and Inspections:

1. Commission system in accordance with installation and operation manual.
2. Inspect for sources of water entry and proper sealing.
3. Inspect weather barrier to confirm that no sharp edges are contacting the trace heating.
4. Minimum Acceptable Insulation Resistance: 20 megohms or greater at a test voltage of 2500 VDC for polymer insulated trace heaters.
5. Test heating cable integrity with megohmmeter at the following intervals:
6. Measure voltage and current at each unit.
7. Controls:

3.5 CLOSEOUT ACTIVITIES

A Demonstrate operation of controls.

B Demonstration: Demonstrate operation of system to Owner's personnel.

1. Use operation and maintenance data as reference during demonstration.
2. Briefly describe function, operation, and maintenance of each component.

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 230533

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SECTION 230548
VIBRATION CONTROLS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Vibration isolation requirements.
- B Vibration-isolated equipment support bases.
- C Vibration isolators.

1.2 RELATED REQUIREMENTS

- A Section 033000 - Cast-in-Place Concrete.

1.3 REFERENCE STANDARDS

- A ASHRAE (HVAC) - ASHRAE Handbook - HVAC Applications; Most Recent Edition Cited by Referring Code or Reference Standard.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate selection and arrangement of vibration isolation components with the actual equipment 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.
- B Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

1.5 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.

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1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification methods for spring element load capacities.

1.6 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.1 VIBRATION ISOLATION REQUIREMENTS

- A Design and provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing HVAC equipment and/or HVAC connections to vibration-isolated equipment.
- B Comply with applicable general recommendations of ASHRAE (HVACA), where not in conflict with other specified requirements:
- C General Requirements:
 1. Select vibration isolators to provide required static deflection.
 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.
- D Piping Isolation:
 1. Provide vibration isolators for piping supports:
 - a. Located in equipment rooms.
 - b. Located within 50 feet (15.2 m) of connected vibration-isolated equipment and pressure-regulating valve (PRV) stations.
 2. Minimum Static Deflection:
 - a. First Three Supports Closest to Isolated Equipment: Same as static deflection of equipment; maximum of 2 inch (50 mm) deflection required.
 - b. Remainder of Supports: 0.75 inch (19 mm) deflection unless otherwise indicated.
 3. Suspended Piping, Nonseismic Applications: Use spring isolator hangers.
 4. Floor-Mounted Piping, Nonseismic Applications: Use open (unhoused) spring isolators.

2.2 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES

- A Manufacturers:
 1. Vibration-Isolated Equipment Support Bases:
 - a. Kinetics Noise Control, Inc
 - b. Mason Industries
 - c. Vibro-Acoustics

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2. Source Limitations: Furnish vibration-isolated equipment support bases and associated components and accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.

B Vibration-Isolated Concrete Inertia Bases:

1. Description: Concrete-filled engineered steel forms with integral mounting provisions for vibration isolators, sized and configured for mounting of equipment.
2. Minimum Base Depth: 6 inches (152 mm).
3. Minimum Base Mass (Including Concrete): 1.5 times weight of supported equipment.
4. Concrete Reinforcement: Welded or tied reinforcing bars running both ways in a single layer.
5. Concrete: Filled on site with minimum 3000 psi (20 mPa) concrete in accordance with Section 033000.

2.3 VIBRATION ISOLATORS

A General Requirements:

1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as shown on the drawings.
- B Verify that mounting surfaces are ready to receive vibration isolation control components and associated attachments.
- C Verify that conditions are satisfactory for installation prior to starting work.

3.2 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 Secure fasteners according to manufacturer's recommended torque settings.
- D Install flexible piping connections to provide sufficient slack for vibration isolation relative displacements as indicated or as required.

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- E Vibration Isolation Systems:
1. Vibration-Isolated Equipment Support Bases:
 - a. Provide specified minimum clearance beneath base.
 2. Spring Isolators:
 - a. Position equipment at operating height; provide temporary blocking as required.
 - b. Lift equipment free of isolators prior to lateral repositioning to avoid damage to isolators.
 - c. Level equipment by adjusting isolators gradually in sequence to raise equipment uniformly such that excessive weight or stress is not placed on any single isolator.
 3. Isolator Hangers:
 - a. Use precompressed isolator hangers where required to facilitate installation and prevent damage to equipment utility connection provisions.
 - b. Locate isolator hangers at top of hanger rods in accordance with manufacturer's instructions.
 4. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.
 5. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
 6. Adjust isolators to be free of isolation short circuits during normal operation.
 7. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.

3.3 FIELD QUALITY CONTROL

- A Inspect vibration isolation control components for damage and defects.
- B Vibration Isolation Systems:
1. Verify isolator static deflections.
 2. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- C Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.

END OF SECTION 230548

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SECTION 230553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Nameplates.
- B Tags.
- C Adhesive-backed labels.
- D Pipe markers.
- E Ceiling tacks.
- F Warning Signs and Labels.

1.2 REFERENCE STANDARDS

- A ASME A13.1 - Scheme for the Identification of Piping Systems; 2023.
- B ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2017.

1.3 SUBMITTALS

- A Label, Marker and Tag Product Data Not Required
- B Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 PRODUCTS

2.1 IDENTIFICATION APPLICATIONS

- A Air Handling Units: Nameplates.

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- B Air Terminal Units: Tags and Ceiling tacks, where located above lay-in ceiling
- C Fan Coil Units: Tags and Ceiling tacks, where located above lay-in ceiling
- D Automatic Controls: Tags. Key to control schematic.
- E Control Panels: Nameplates.
- F Dampers: Ceiling tacks, where located above lay-in ceiling.
- G Ductwork: Adhesive Backed Labels.
- H Heat Transfer Equipment: Nameplates.
- I Piping: Pipe markers.
- J Pumps: Nameplates.
- K Tanks: Nameplates.
- L Thermostats: Nameplates to device it controls.
- M Valves: Tags and ceiling tacks where located above lay-in ceiling.
- N Water Treatment Devices: Nameplates.

2.2 NAMEPLATES

- A Letter Color: White.
- B Letter Height: 1/4 inch (6 mm).
- C Background Color: Black.
- D Plastic: Comply with ASTM D709.

2.3 TAGS

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- A Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch (40 mm) diameter with smooth edges.
- B Valve Tag Chart: Typewritten letter size list in anodized aluminum frame. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Include valve-tag schedule in operation and maintenance data.

2.4 ADHESIVE-BACKED DUCT LABELS

- A Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch (0.76 mm); printed with UV and chemical resistant inks.
- B Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C Letter Color: White.
- D Provide labels in the following color codes:
 - 1. White on Blue for supply and outside air ducts.
 - 2. White on Green for return air ducts.
 - 3. Black on Yellow for exhaust and relief-air ducts.
- E Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on drawings, and an arrow indicating flow direction.

2.5 PIPE MARKERS

- A Colors: Comply with ASME A13.1.
 - 1. Potable, Chilled, Heating, and Other Water: White on Green.
 - 2. Steam and Condensate Piping: Black on Yellow.
- B 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.
- C Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings.

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- D Underground Plastic Pipe Markers: Bright-colored continuously printed plastic ribbon tape, minimum 6 inches (150 mm) wide by 4 mil, 0.004 inch (0.10 mm) thick, manufactured for direct burial service.

2.6 CEILING TACKS

- A Description: Steel with 3/4 inch (20 mm) diameter color coded head.
- B Color code as follows:
 - 1. HVAC Equipment: Yellow.
 - 2. Fire Dampers and Smoke Dampers: Red.
 - 3. Heating/Cooling Valves: Blue.

2.7 WARNING SIGNS AND LABELS

- A Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B Color: White on Red
- C Temperature: Able to withstand temperatures up to 160 deg F.
- D Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- E Minimum Letter Size: 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances.
- F Fasteners: Stainless-steel rivets or self-tapping screws.
- G Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H In paragraph below, describe required label content. The objective of labeling equipment is to coordinate it with Drawings, including plans, details, and schedules. This will allow other information, such as capacities and operating characteristics, to be obtained.
- I Label Content: Include caution and warning information, plus emergency notification instructions.

PART 3 EXECUTION

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3.1 PREPARATION

- A Degrease and clean surfaces to receive adhesive for identification materials.

3.2 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. Use for bare or insulated pipe applications.
- D Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions. Use for insulated pipe applications only.
- E Install underground plastic pipe markers 6 to 8 inches (150 to 200 mm) below finished grade, directly above buried pipe.
- F Locate duct labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.
- G Locate and install pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations. Labels shall be spaced at maximum intervals of 50 feet along each run.
- H Install tags on valves and control devices in piping systems, List tagged valves in a valve schedule in the operating and maintenance manual.
 - 1. Exceptions : Check valves, valves within factory-fabricated equipment units, shutoff valves.
- I Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 230553

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SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Testing, adjustment, and balancing of air systems.
- B LEED Requirements.
- C Commissioning activities.

1.2 RELATED REQUIREMENTS

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

1.3 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.
- C SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2023.

1.4 SUBMITTALS

- A 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 at least one month prior to starting the testing, adjusting, and balancing work.
 - 2. Include certification that the plan developer has reviewed Contract Documents, the equipment and systems, and the control system with the Architect and other installers to sufficiently understand the design intent for each system.
- B Final Certified TAB Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.

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1. Revise TAB plan to reflect actual procedures and submit as part of final report.
2. 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.
3. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
4. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
5. Units of Measure: Report data in I-P (inch-pound) units only.

C LEED Submittals

1. Air-Balance Report for LEED Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2, "Air Balancing."
2. TAB report : Documentation indicating that Work complies with ASHRAE 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.1 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. 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.

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- F Pre-Qualified TAB Agencies:
1. Enviro Aire
 2. Others at the approval of the Owner prior to bidding.

3.2 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, fire/smoke, 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 meets the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts".
 12. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
 13. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning
 14. Hydronic systems are flushed, filled, and vented.
 15. Pumps are rotating correctly.
- B Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.

3.3 PREPARATION

- A Hold a pre-balancing meeting at least one week prior to starting TAB work.

3.4 ADJUSTMENT TOLERANCES

- A Air Handling Systems: Adjust to within plus 10 percent 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 individual outlets and inlets in space to within plus or minus 10 percent of design.

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3.5 RECORDING AND ADJUSTING

- A Ensure recorded data represents actual measured or observed conditions.
- B Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- D Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.6 FUME HOOD TESTING (ON SITE)

- A General: Test fume hoods as installed to assess airflow velocity, airflow visualization, and level of containment. Perform tests with static mode (set sash position) conditions. Conduct testing as outlined below for 100% of the hoods provided in the Project.
- B Preparation: Visit the project site to confirm that construction activities related to the fume hood system(s) and equipment are complete. Review design documents and Contractor's submittals. Verify that mechanical ventilation systems serving the space are functioning and operating in the normal mode. Notify Owner in writing, if conditions exist which preclude proper fume hood testing. Starting of testing constitutes acceptance of site conditions.

3.7 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.
 - 1. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
- C Measure air quantities at air inlets and outlets.
- D Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
- E Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.

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- F 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.
- G Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- H Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan.
 - 1. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - 2. Measure static pressure directly at the fan outlet or through the flexible connection.
 - 3. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - 4. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
- I Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- J Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- K Where modulating dampers are provided, take measurements and balance at extreme conditions.
- L Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches (12.5 Pa) positive static pressure near the building entries.
- M Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

3.8 VARIABLE-AIR-VOLUME (VAV) PROCEDURES

- A Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

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- B After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record final fan-performance data.
- C On fan powered VAV boxes, adjust air flow switches for proper operation.
- D Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.

3.9 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.

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- 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 (diversity in the system) or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.
- G Check makeup water-station pressure gage for adequate pressure for highest vent.
- H Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded, or inform Engineer if pump does not have a flow control device at the discharge of the pump.
- I Triple duty valves should be kept fully open on pumps with VFDs unless balancing results indicate the system balancing valve needs to be adjusted. If triple duty valve is not fully open at the conclusion of balancing it should be noted in the report.
- J Systems installed with pressure independent control valves shall not require full hydronic system balancing. Flow shall be verified for the pressure independent valve assembly (valve and actuator combination) for field conditions using the pressure independent control valve manufacturer's documented procedure for [20%] [50%] [100%] of the total installed product. Exact locations of tested product to be coordinated with the drawings.

3.10 COMMISSIONING

- A See Sections 019113 - General Commissioning Requirements and 230800 for additional requirements.
- B Perform prerequisites prior to starting commissioning activities.
- C Fill out Prefunctional Checklists for:
 - 1. Air side systems.
 - 2. Water side systems.
- D Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.
- E Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for 100 percent of the air handlers plus a random sample equivalent to 100 percent of the final TAB report data as directed by Commissioning Authority.
 - 1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
 - 2. Use the same test instruments as used in the original TAB work.

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3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
 4. For purposes of re-check, failure is defined as follows:
 - a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.
 - b. Minimum Outside Air Flow: Deviation of more than 20 percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
 - c. Temperatures: Deviation of more than one degree F (0.5 degree C).
 - d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
 - e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
 5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.
- F In the presence of the Commissioning Authority, verify that:
1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
 2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
 3. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

3.11 SCOPE

- A Test, adjust, and balance the following:
1. Fire Pumps.
 2. Domestic Water booster Pump.
 3. Boiler.
 4. Water Heater.
 5. Steam Humidifier.
 6. HVAC Pumps.
 7. Heat Exchanger.
 8. Air Cooled Water Chillers.
 9. Air Handling Units.
 10. Fans.

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11. Air Terminal Units.
12. Air Inlets and Outlets.
13. Fan Coil Units.

3.12 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. Sheave Make/Size/Bore.

B 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.

C Combustion Equipment:

1. Boiler manufacturer.
2. Model number.
3. Serial number.
4. Entering and Leaving Water Temperatures
5. Flow Rate

D Chillers:

1. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 2. Identification/number.
 3. Manufacturer.
 4. Capacity.

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5. Model number.
6. Serial number.
7. Evaporator entering water temperature, design and actual.
8. Evaporator leaving water temperature, design and actual.
9. Evaporator pressure drop, design and actual.
10. Evaporator water flow rate, design and actual.
11. Condenser entering water temperature, design and actual.
12. Condenser pressure drop, design and actual.
13. Condenser water flow rate, design and actual.
14. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

E Heat Exchangers:

1. Identification/number.
2. Location.
3. Service.
4. Manufacturer.
5. Model number.
6. Serial number.
7. Primary water entering temperature, design and actual.
8. Primary water leaving temperature, design and actual.
9. Primary water flow, design and actual.
10. Primary water pressure drop, design and actual.
11. Secondary water leaving temperature, design and actual.
12. Secondary water flow, design and actual.
13. Secondary water pressure drop, design and actual.

F Heating and 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.

G Exhaust Fans:

1. Location.

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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.

H Return Air/Outside Air (Air Handling):

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.

I 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.

J Air Distribution Tests:

1. Air terminal number.
2. Room number/location.
3. Terminal type.
4. Terminal size.

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

END OF SECTION 230593

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SECTION 230713
DUCT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Duct insulation.
- B Duct liner.
- C Fire Wrap Duct Insulation

1.2 REFERENCE STANDARDS

- A ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2021.
- B ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2023.
- C ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013 (Reapproved 2019).
- D ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014 (Reapproved 2019).
- E ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation; 2020.
- F ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2023.
- G ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015, with Editorial Revision (2021).
- H SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.

1.3 SUBMITTALS

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- A Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.
- C LEED Submittal : Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

1.4 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.

1.5 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.

1.6 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

2.1 GLASS FIBER, FLEXIBLE

- A Manufacturer:
 - 1. CertainTeed Corporation
 - 2. Johns Manville
 - 3. Knauf Insulation
 - 4. Owens Corning Corporation
- B Insulation: ASTM C553; flexible, noncombustible blanket.

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1. K (Ksi) value: 0.36 at 75 degrees F (0.052 at 24 degrees C), when tested in accordance with ASTM C518.
 2. Maximum Service Temperature: 1,200 degrees F (649 degrees C).
 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 (0.029 ng/(Pa s m)), 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 Vapor Barrier Mastic:
1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
 2. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24) .

2.2 GLASS FIBER, RIGID

- A Manufacturer:
1. CertainTeed Corporation
 2. Johns Manville
 3. Knauf Insulation
 4. Owens Corning Corporation
- B Insulation: ASTM C612; rigid, noncombustible.
1. K (Ksi) Value: 0.24 at 75 degrees F (0.036 at 24 degrees C), when tested in accordance with ASTM C518.
 2. Maximum Service Temperature: 450 degrees F (232 degrees C).
 3. Maximum Water Vapor Absorption: 5.0 percent.
 4. Maximum Density: 8.0 pcf (128 kg/cu m).
- C Vapor Barrier Jacket:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing
 2. Moisture Vapor Permeability: 0.02 perm inch (0.029 ng/(Pa s m)), when tested in accordance with ASTM E96/E96M.
 3. Secure with pressure-sensitive tape.
- D Vapor Barrier Tape:
1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic or pressure-sensitive rubber-based adhesive.

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2.3 FIRE WRAP DUCT INSULATION

- A Products: Subject to compliance with requirements, provide one of the following:
 - 1. 3M Fire Barrier Duct Wrap Type 15A
 - 2. UNIFRAX Fyrewrap
 - 3. Thermal Ceramics Firemaster
- B Joint free, lightweight, non-asbestos, high temperature, inorganic foil encapsulated ceramic fiber blanket duct wrap for use on commercial grease hood duct systems in accordance with ASTM E2336.
- C A zero inch clearance to combustible construction and two (2) hour fire resistive rated enclosure system shall be assured.
- D Adhesives: High performance filament tape, one inch wide, and aluminum foil tape to seal cut edges of blankets.
- E Banding Material: Two (2) hour requirement, $\frac{3}{4}$ " wide, no less than 0.015 inches thick, Type 304 stainless steel, (stainless steel hose clamps, $\frac{1}{2}$ inch may be substituted for hanger insulations only).
- F Insulation Pins: 10 gage, 4 inches to 5 inches long, copper coated steel no less than 1-1/2 inch by 1-1/2 inch or 1-1/2 inch diameter galvanized steel speed clip.
- G Fire Stopping Materials: UL No R9464 classified noncombustible fiber with a flame spread of 0, smoke development of 0 and fuel contribution of 0. Water based, mild chemical resistant putty complying with ASTM E136-82 may be used.

2.4 DUCT LINER

- A Manufacturers:
 - 1. CertainTeed Corporation
 - 2. Johns Manville
 - 3. Knauf Insulation
 - 4. Owens Corning Corporation
- B Elastomeric Foam Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
 - 1. Minimum Service Temperature: Minus 40 degrees F (Minus 40 degrees C).
 - 2. Maximum Service Temperature: 180 degrees F (82 degrees C).
 - 3. Fungal Resistance: No growth when tested according to ASTM G21.
 - 4. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F (0.045 at 24 degrees C).

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5. Connection: Waterproof vapor barrier adhesive.

- C Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. Comply with ASTM C916.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 GENERAL INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- C Continue insulation through walls, floors, roofs, sleeves, hangers, and other duct penetrations.
1. Extend jacket of outdoor insulation outside roof or above ground exterior wall flashing at least 2 inches below top of flashing.
 2. Seal jacket to flashing with flashing sealant.
- D Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
- E Insulate entire system, including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- F Insulated Ducts Conveying Air Below Ambient Temperature:
1. Provide insulation with vapor barrier jackets.
 2. Finish with tape and vapor barrier jacket.
 3. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
- G Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

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- H Install insulation in a manner to avoid compressing the insulation more than 10 percent.
- I Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- J Keep insulation materials dry during application and finishing.
- K 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.

3.3 INSTALLATION OF GLASS-FIBER INSULATION

- A Blanket and Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- B Comply with manufacturer's written installation instructions.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Impale insulation over pins and attach speed washers.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

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- a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
- b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6 inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.4 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A Comply with manufacturer's written installation instructions and ASTM C1710.
- B Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C Square and Rectangular Ducts and Plenums:
1. Provide 1/4 inch more per side for a tight, compression fit.
 2. Cut sheet insulation with the following dimensions:
 - a. Width of duct plus 1/4 inch, one piece.
 - b. Height of duct plus 1/4 inch, plus thickness of insulation, two pieces.
 - c. Width of duct plus 1/4 inch, plus two times the thickness of insulation, one piece.
 3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.
 4. Insulation without self-adhering backing:
 - a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last 1/4 inch where sheets will butt together.
 - b. Roll sheet down into position.
 - c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.
 5. Insulation with self-adhering backing:
 - a. Peel back release paper in 6- to 8-inch increments and line up sheet.
 - b. Press firmly to activate adhesive.
 - c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.
 - d. Allow 1/4-inch overlap for compression at butt joints.
 - e. Apply adhesive at the butt joint to seal the two sheets together.
 6. Insulate duct brackets following manufacturer's written installation instructions.

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- D Circular Ducts:
1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
 2. Cut the sheet to the required size.
 3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
 4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.

3.5 DUCT INSULATION SCHEDULES

- A Combustion Air Duct or Pipe:
1. Mineral-fiber blanket 1-1/2 inches thick.
- B Exhaust Ducts and Plenums
1. Concealed or exposed exhaust between isolation damper and penetration of building exterior. Mineral-fiber blanket, 2 inches thick and 0.75-lb/cu. ft. nominal density.
- C Outside Air Intake Ducts and Plenums
1. Exposed:
 - a. Mineral-fiber board, 1-1/2 inches thick and 3-lb/cu. ft. nominal density.
 - b. Flexible Elastomeric, 1-1/2 inches thick.
 2. Concealed : Mineral-fiber blanket, 2 inches thick and 0.75-lb/cu. ft. nominal density.
- D Supply Ducts and Plenums
1. Concealed : Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 2. Exposed in an indirectly conditioned space (an enclosed space in the building that maintains between 60 and 85 degrees) I.E. Mechanical Room, Storage Room
 - a. Mineral-fiber board, 1 inch thick and 3-lb/cu. ft. nominal density.
 - b. Flexible Elastomeric, 1 inch thick.
 - c. Mineral-fiber blanket, 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 3. Exposed in UnconditionedSpace (I.E. Crawlspace, Attic)
 - a. Mineral-fiber board, 1-1/2 inches thick and 3-lb/cu. ft. nominal density.
 - b. Flexible Elastomeric, 1-1/2 inches thick.
 - c. Mineral-fiber blanket, 2-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 4. Exposed supply air in a conditioned space: Internal duct liner, 1 inch thick.
- E Supply ducts Five (5) Feet after Terminal Boxes
1. Rectangular
 - a. Flexible Elastomeric liner, 1 inch thick.
 2. All branch take offs shall occur after a minimum of 5 feet of lined duct. If a takeoff occurs within the first 5 feet, then the branch shall be insulated to meet the 5 feet minimum insulation requirement.

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F Fume Hood Exhaust Duct:

1. Insulated with 2-hour rated duct wrap.

G Applications not requiring insulation:

1. Return ducts in return air plenum or fully conditioned spaces
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

END OF SECTION 230713

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SECTION 230719
HVAC PIPING AND EQUIPMENT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Piping insulation.
- B Equipment Insulation
- C Jacketing and accessories.

1.2 REFERENCE STANDARDS

- A ASTM B209/B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2021a.
- B 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).
- C ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2023.
- D ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2022a.
- E ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2023).
- F ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- G ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials; 2023.
- H UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.3 SUBMITTALS

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- A Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.
- C LEED Submittal : Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

1.4 QUALITY ASSURANCE

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 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

2.1 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.

2.2 GLASS FIBER, RIGID

- A Manufacturers:
 - 1. CertainTeed Corporation
 - 2. Johns Manville Corporation
 - 3. Knauf Insulation
 - 4. Owens Corning Corporation

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- 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 (Ksi) Value: ASTM C177, 0.23 at 75 degrees F (0.034 at 24 degrees C).
 - 2. Maximum Service Temperature: 220 degrees F (104 degrees C).
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.

2.3 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A Manufacturers:
 - 1. Aeroflex USA; AEROFLEX Self-Seal
 - 2. Armacell LLC; ArmaFlex Ultra with FlameDefense
 - 3. K-Flex USA LLC; Insul-Tube
- 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 (Minus 40 degrees C).
 - 2. Maximum Service Temperature: 180 degrees F (82 degrees C).
 - 3. Connection: Waterproof vapor barrier adhesive.
- C Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.
- D Outdoor Application - Products: Subject to compliance with requirements, provide one of the following:
 - 1. ArmaFlex Shield (with integral durable protective jacket) UV resistant.
 - 2. ArmaTuff (with integral 12 mil laminated covering membrane)

2.4 INSULATING CEMENTS

- A Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- B For indoor applications, use cement that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.5 ADHESIVES

- A Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B Adhesives to be waterproof fire-retardant type.

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- C For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 MASTICS

- A Materials shall be compatible with insulation materials, jackets, and substrates.
- B For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- D Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 200 deg F.
 - 3. Solids Content: 63 percent by volume and 73 percent by weight.
 - 4. Color: White.

2.7 SEALANTS

- A Joint Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Permanently flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 100 to plus 300 deg F.
 - 4. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.8 TAPES

- A ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Adhesion: 90 ounces force/inch in width.
 - 3. Elongation: 2 percent.
 - 4. Tensile Strength: 40 lbf/inch in width.

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- B FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches.
 - 2. Adhesion: 90 ounces force/inch in width.
 - 3. Elongation: 2 percent.
 - 4. Tensile Strength: 40 lbf/inch in width.

- C PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 - 1. Width: 2 inches.
 - 2. Thickness: 6 mils.
 - 3. Adhesion: 64 ounces force/inch in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch in width.

2.9 JACKETING AND ACCESSORIES

- A PVC Plastic.
 - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: 0 degrees F (minus 18 degrees C).
 - b. Maximum Service Temperature: 150 degrees F (66 degrees C).
 - c. Moisture Vapor Permeability: 0.002 perm inch (0.0029 ng/(Pa s m)), maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil, 0.010 inch (0.25 mm).
 - e. Connections: Brush on welding adhesive.

- B Aluminum Jacket:
 - 1. Comply with ASTM B209/B209M, Temper H14, minimum thickness of 0.016 inch (0.41 mm) with factory-applied polyethylene and kraft paper moisture barrier on the inside surface.
 - 2. Thickness: 0.016 inch (0.40 mm) sheet.
 - 3. Finish: Smooth.
 - 4. Joining: Longitudinal slip joints and 2 inch (50 mm) laps.
 - 5. Fittings: 0.016 inch (0.40 mm) thick die-shaped fitting covers with factory-attached protective liner.
 - 6. Metal Jacket Bands: 3/8 inch (10 mm) wide; 0.015 inch (0.38 mm) thick aluminum.

2.10 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.

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3. Comply with ASTM C795 requirements for materials to be used on stainless steel surfaces.
4. Supply materials that are asbestos free.

PART 3 EXECUTION

3.1 EXAMINATION

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

3.2 GENERAL INSTALLATION OF INSULATION

- A Install in accordance with manufacturer's instructions.
- B Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
- C Exposed Piping and 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 Insulated Pipes Conveying Fluids Below Ambient Temperature:
 1. Insulate entire system, including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- H For hot piping conveying fluids over 140 degrees F (60 degrees C), insulate flanges and unions at equipment.
- I Glass Fiber Insulated Pipes Conveying Fluids Above Ambient Temperature:

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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.
- J Inserts and Shields:
1. Application: Piping 1-1/2 inches (40 mm) 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 (150 mm) 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.
- K Continue insulation through walls, floors, roof, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.
1. Extend jacket of outdoor insulation outside roof or above ground exterior wall flashing at least 2 inches below top of flashing.
 2. Seal jacket to flashing with flashing sealant.
 3. Seal penetrations through fire-rated assemblies.
- L Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- M Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.
- N Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- O Install insulation in a manner to avoid compressing the insulation more than 10 percent.
- P Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- Q Keep insulation materials dry during application and finishing.
- R Exterior Applications:
1. Provide insulation with a factory applied cladding, zero permeability, and UV resistant.
 2. 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.

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- S 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.

3.3 GENERAL PIPE INSULATION INSTALLATION

- A Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

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- B Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- C Install removable insulation covers where required for access or maintenance.

3.4 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

- A Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.
 - 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.5 FIELD-APPLIED JACKET INSTALLATION

- A Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.

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4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
- C Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.6 SCHEDULE

- A Heating Systems:
1. Heating Water Supply and Return (Less than 200 degrees F):
 - a. Glass-Fiber, Preformed Pipe
 - b. Pipe Sizes less than 1-1/2 inches : 1.5 inches thick
 - c. Pipe Sizes 1-1/2 and up : 2.0 inches thick
 - d. Outdoor All Pipe Sizes : 2.0 inches thick With Factory Cladding or Aluminum Jacket
 - 1) Provide heat trace on exterior piping.
 2. Low Pressure Steam (Less than 250 degrees F):
 - a. Glass-Fiber, Preformed Pipe
 - b. Pipe Sizes less than 2 inches : 2.5 inches thick
 - c. Pipe Sizes 2 inches and up : 3.0 inches thick
- B Cooling Systems:
1. Indoor Chilled Water:
 - a. Flexible Elastomeric
 - b. Pipe Sizes 6 inches and less : 1.0 inches thick
 - c. Pipe Sizes over 6 inches : 1.5 inches thick
 2. Outdoor Chilled Water
 - a. Flexible Elastomeric with Aluminum Jacket
 - b. Pipe Sizes 3 inches and less : 1.0 inches thick
 - c. Pipe Sizes over 3 inches : 1.5 inches thick
 - d. Provide heat trace on exterior piping.
 3. Cold Condensate Drains and Piping (All Pipe Sizes)
 - a. Flexible Elastomeric or Polyolefin: minimum 3/4 inch thick.
 - b. Glass-Fiber, Preformed Pipe Insulation, Type I: minimum 1/2 inch thick.
- C Heating System Equipment

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1. Reheat Coils : VAV and FPVAV reheat coil sections shall have field installed insulation, covering the exposed coil U-bends on both sides of the coil section, coil headers, and the entire reheat section. GlassFiber, Flexible, 1 inch thick.
 2. Heat Exchangers : Glass-fiber pipe and tank, 2 inches thick.
- D Cooling (Chilled Water) System Equipment
1. Pump Bodies : Flexible Elastomeric. 1 inch thick for Pumps less than 20 HP, and 1.5 inches thick for Pumps 20 HP and over.
 2. Air Separators : Flexible Elastomeric: 1 inch thick.
 3. Expansion Tanks : Not Required.

END OF SECTION 230719

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SECTION 230800

COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.
- B. The OPR and BOD documentation are included by reference for information only.
- C. Division 01 section 'LEED Requirements' for additional LEED requirements.

1.2 SUMMARY

- A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.
- E. O&M manuals

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- F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

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PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. **Red-lined Drawings:** The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. **Operation and Maintenance Data:** Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. **Demonstration and Training:** Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meetings.
- C. Attend testing, adjusting, and balancing review and coordination meetings.
- D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- E. Provide information requested by the CxA for final commissioning documentation.
- F. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- G. Prepare preliminary schedule for Mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing, flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.
- H. Update schedule as required throughout the construction period.
- I. Assist the CxA in all verification and functional performance tests.

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- J. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- K. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- L. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- M. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- N. Participate in, and schedule vendors and contractors to participate in the training sessions.
- O. Provide written notification to the CM/GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Ductwork
 - 2. Hydronic Piping
 - 3. Energy Recovery Units
 - 4. Fan Coil Units
 - 5. Exhaust Fans
 - 6. Stair Pressurization Fans
 - 7. Variable Air Volume Units
 - 8. Supply/Exhaust Lab Units
 - 9. Air Cooled Chillers
 - 10. Hot Water Boilers
 - 11. Hydronic Pumps
 - 12. Plate & Frame Heat Exchangers
 - 13. Cabinet Unit Heaters
 - 14. Unit Heaters
 - 15. Air Curtains
 - 16. Building Management System
- P. The equipment supplier shall document the performance of his equipment.
- Q. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- R. Test, Adjust and Balance Contractor
 - 1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
 - 2. Submit the site specific testing and balancing plan to the CxA and AE for review and acceptance.
 - 3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
 - 4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the CM/GC.
 - 5. At the completion of testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R Contractor and the CM/GC.

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6. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.

S. Equipment Suppliers

1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
2. Assist in equipment testing per agreements with contractors.
3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

- T. Refer to Division 01 Section "General Commissioning Requirements" for additional contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

3.5 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.

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- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 TESTING, ADJUSTING AND BALANCING VERIFICATION

- A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.8 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the HVAC&R contractor, testing and balancing Subcontractor, and HVAC&R Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

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- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.9 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 23 sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. **HVAC&R Instrumentation and Control System Testing:** Field testing plans and testing requirements are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls." Assist the CxA with preparation of testing plans.
- C. **Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment:** Test requirements are specified in Division 23 piping Sections. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. **Refrigeration System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- E. **HVAC&R Distribution System Testing:** Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- F. **Vibration and Sound Tests:** Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

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- G. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:

1. Ductwork
2. Hydronic Piping
3. Energy Recovery Units
4. Fan Coil Units
5. Exhaust Fans
6. Stair Pressurization Fans
7. Variable Air Volume Units
8. Supply/Exhaust Lab Units
9. Air Cooled Chillers
10. Hot Water Boilers
11. Hydronic Pumps
12. Plate & Frame Heat Exchangers
13. Cabinet Unit Heaters
14. Unit Heaters
15. Air Curtains
16. Building Management System

3.10 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.11 APPROVAL

- A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.

3.12 DEFERRED TESTING

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.

3.13 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section "General Commissioning Requirements" for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

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3.14 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to training.

END OF SECTION 230800

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SECTION 230913
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Control panels.
- B Control Valves:
 - 1. Ball valves with factory-mounted actuators.
 - 2. Butterfly valves with factory-mounted actuators.
 - 3. Electronic valve operators.
- C Damper Operators:
 - 1. Electric operators.
- D Wall-, Surface-, and Duct-Mounted Sensors:
 - 1. Temperature sensors.
 - 2. Humidity sensors.
 - 3. Building static pressure transmitters.
 - 4. Room pressure monitors.
 - 5. Airflow meters; pitot tubes.
 - 6. Carbon monoxide sensors.
- E Thermostats:
 - 1. Room-mount thermostat accessories.
- F Fan and pump motor run-status monitoring.
- G Pipe-Mounted Sensors and Transmitters:
 - 1. Temperature sensors.
 - 2. Pressure transmitters.
 - 3. Differential pressure transmitters.
 - 4. Flow switches.
 - 5. Electromagnetic flow meter
 - 6. Thermal mass flow meters.
- H Energy Metering:
 - 1. Hydronic energy meters.

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1.2 RELATED REQUIREMENTS

- A Section 232113 - Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, and gauge taps.
- B Section 232114 - Hydronic Specialties.
- C Section 233300 - Air Duct Accessories.
- D Section 262726 - Wiring Devices: Elevation of exposed components.

1.3 REFERENCE STANDARDS

- A ANSI/FCI 70-2 - Control Valve Seat Leakage; 2021.
- B IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code); 1989 (Corrigendum 2019).
- C NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Preinstallation Meeting: Conduct a preinstallation meeting one week before starting work of this section; require attendance by all affected installers.

1.5 SUBMITTALS

- A 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.
- B 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.
- C Project Record Documents: Record actual location of control components, including panels, thermostats, and sensors.
 - 1. Revise shop drawings to reflect actual installation and operating sequences.

1.6 QUALITY ASSURANCE

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

1.7 WARRANTY

- A Correct defective work within a five year period after Substantial Completion.

PART 2 PRODUCTS

2.1 EQUIPMENT - GENERAL

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

2.2 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.

2.3 CONTROL VALVES

- A Ball Valves with Factory-Mounted Actuators:
1. Service: Use for brine (30 percent glycol), chilled water, hot water, or steam at 15 to 25 psig (104.4 to 172.4).
 2. Flow Characteristic: Include 2-way and 3-way diverting operation configured to fail normally closed (NC).
 3. Replacements in Kind: Provide pressure-independent type.
 4. Rangeability: 500 to 1.
 5. ANSI Rating: Class 150.
 6. Leakage: Class IV (0.1 percent of rated capacity) per ANSI/FCI 70-2.
 7. Body Size:
 - a. Service Temperature:
 - 1) Fluid Side: 0 to 284 degrees F (0 to 140 degrees C) liquid or 25 psig (172.4 kPa) steam.
 - 2) Ambient Side: From minus 4 to 122 degrees F (minus 20 to 50 degrees C).
 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 Butterfly Valves with Factory-Mount Actuators:

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C 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.

2.4 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 (3.34 sq m) 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.

2.5 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 (26 degrees C).
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. Room Sensors: Locking cover matching the pneumatic thermostats used.
 - b. Room Temperature Sensors:
 - 1) Construct for surface or wall box mounting.
 - 2) Provide the following:
 - (a) Setpoint reset slide switch with an adjustable temperature range.
 - (b) Individual heating/cooling setpoint slide switches.
 - (c) Momentary override request push button for activation of after-hours operation.

B Humidity Transmitters, Surface-Mounted:

1. Plastic housing encased, wall-mounted, humidity and temperature indicating sensor.
2. Humidity Sensor Type: Thin-film capacitive.

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3. Accuracy: 1 percent at rated measuring scale and capable of withstanding 95 percent relative humidity without loss of calibration.
4. Output: Two-wire, 4 to 20 mA, 0 to 5 VDC or 0 to 10 VDC, non-loop powered, selectable.

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 (.0025 to 1.5 kPa) positive or negative, and sensitivity of 0.0005 in-wc (0.125 Pa). Transmit electronic signal to receiver with matching scale range.

D Room Pressure Monitors:

1. Transmitter: Five percent accuracy, adjustable zero and span, 100 to 1 turndown, 0.1 percent of calibrated span linearity, 30 to 50 millisecond response time, minimum overpressure of 150 percent over highest range value, alphanumeric indicating display, wired or wireless connectivity for configuration, and terminal strip within enclosed electronic components.

E Airflow Meters; Pitot Tubes:

1. Sensor Type: Provide duct-inserted probe, duct-inserted pitot-tube assembly, and wall-mounted assembly for outside air with built-in transmitter.
2. Flow Range: Equivalent velocity pressure required to match scheduled flow range with a 100 to 1 signal turndown ratio.
3. Linearity: 0.1 percent of calibrated span.
4. Minimum Overpressure: 150 percent over highest range value.
5. Output: Two-wire, 4 to 20 mA.
6. Access Box: NEMA EN 10250, Type 1 with hinged cover housing and cable access ports.

F 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.

2.6 THERMOSTATS

A Room-Mounted Thermostat Accessories:

1. Thermostat Covers: Brushed aluminum.
2. Insulating Bases: For thermostats located on exterior walls.

2.7 FAN AND PUMP MOTOR RUN-STATUS MONITORING

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A Current Switches:

1. Maximum AC Current Monitoring Value: As indicated on drawings.

B Differential Pressure Switches:

1. Fan Status: Select for adjustable range between 0 to 5 in-wc (0 to 1,250 Pa) across fan discharge and external or fan inlet. Include static pressure taps.
2. Pump Status: Select for adjustable range between 8 to 60 psi (50 to 400 kPa) across pump discharge and suction sides. Include static pressure taps and 3-way valve manifold.

2.8 PIPE-MOUNTED SENSORS AND TRANSMITTERS

A Temperature Sensors:

1. Pipe-mounted temperature probe tied to weather-resistant enclosure for direct insertion into compatible liquids or gases or inserted into intermediary thermal grease-filled pipe-well compatible with interfaced fluid.
2. Sensor Type: 1,000 ohm Platinum RTD.

B Pressure Transmitters:

1. Self-contained transducer for monitoring of pneumatic, gas, liquid, or steam service with proportional range scaled over selected electronic output.
2. Service Monitoring Range: 0 to 15 psig (0 to 1 bar).
3. Wetted Material: Brass for general service or stainless steel for steam and corrosive.
4. Hardwired Output: Two-wire, 4 to 20 mA, loop powered.

C Differential Pressure Transmitters:

1. General: Provide wet media differential pressure transducers with 6 ft (1.83 m) armored cable, to allow local or remote pressure sensing capability using existing plumbing runs.
 - a. Output: 3-wire transmitter; 4 to 20 mA, 0 to 5V, or 0 to 10V, selectable,
 - b. Sensor:
 - 1) Media Compatibility: 17 to 4 PH stainless steel.
 - 2) Status Indication: Dual color LED.
 - 3) Proof Pressure: 2x max. F.S. range.
 - 4) Burst Pressure: 5x max. F.S. range.
 - 5) Accuracy at 77 degrees F (25 degrees C) for less than or equal 20 ft (6.1 m):
 - 6) Surge Damping: Electronic; 1 second averaging.
 - 7) Long Term Stability: Plus/minus 0.25 percent.
 - c. Pressure Ranges:
 - d. Enclosure: NEMA EN 10250, Type 4.

D Flow Switches:

1. Repetitive Accuracy: Plus/minus 10 percent of actual flow setting.
2. Switch Actuation: Adjustable over the operating range and sized for the application, such that the setpoint is between 25 and 75 percent of the full range.
3. Provide Form C snap-action contacts, rated for the application.

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4. Furnish nonflexible paddle with magnetically actuated contacts, rated for service at a pressure greater than the installed conditions.

E Electromagnetic Flow Meters:

1. Conductive Liquid Flow Capacity Range: As indicated on drawings.
2. Construction: Stainless steel or aluminum sensor integral to NEMA EN 10250 Type 4 or 4X stainless steel or aluminum enclosure with numeric display for consumption reading.
3. Liquid Conductivity: 5 mS/cm, minimum.
4. Accuracy: 0.02 percent of value applied to manufacturer specified velocity range.
5. Hardwired Output: Two-wire, 0 to 10 VDC, non-loop powered.
6. Service Pressure and Temperature: Up to 400 psi (27.6 bar) and 15 to 250 degrees F (minus 9.4 to 125.6 degrees C) liquid side, 150 degrees F (65.5 degrees C) ambient.

2.9 ENERGY METERING

A Hydronic Energy Meters:

1. Factory configured to dynamically monitor, calculate, and output energy demand based on user configured field setting via the front panel keypad or computer interface.
2. Integral transmitter to provide a linear analog or configurable pulse output signal representing the energy rate.

B Power Metering and Sub-metering:

PART 3 EXECUTION

3.1 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.

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- G Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

3.2 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 (1500 mm) above floor. Align with lighting switches and humidistats; see Section 262726.
- 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.
- D Any additional controls power circuits required, temperature controls contractor shall provide additional 120V circuits as required to the 24V transformers. Coordinate with electrical contractor for location of a

END OF SECTION 230913

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SECTION 230923
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 RELATED REQUIREMENTS

- A Section 230913 - Instrumentation and Control Devices for HVAC.

1.3 REFERENCE STANDARDS

- A ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).
- B MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests; 2022h, with Editorial Revision.

1.4 WARRANTY

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

PART 2 PRODUCTS

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2.1 FRONT END

- A Manufacturers
 - 1. Vykon Jace - Tridium

2.2 FIELD LEVEL CONTROLLERS

- A Manufacturers
 - 1. Siemens PXC, PXC.A, DXR Lines
 - 2. Johnson Controls N4 compatible Facility Explorer
 - 3. Honeywell Niagara N4 compatible Optimizer

2.3 LAB CONTROLLERS

- A Manufacturers (matching venturi air valves)
 - 1. Phoenix
 - 2. Antec
 - 3. Critical Room Controls (CRC)

2.4 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 Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

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2.5 OPERATOR INTERFACE

- A PC Based Work Station:
- B Workstation, controllers, and control backbone to communicate using BACnet protocol and addressing.
- C BACnet protocol to comply with ASHRAE Std 135.
- D Hardware:
 - 1. Laptop:
 - a. Computer work station to be provided by owner that is issued by the owner's IT group and complies with the owner's IT standards.

2.6 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 (4 to 65 degrees C).
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.

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- 2) Rated for operation at 32 to 120 degrees F (0 to 50 degrees C).
 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 (1 m).
- 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 (4 to 65 degrees C).
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F (0 to 50 degrees C).
 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.

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- 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 (1 m).

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 (4 to 65 degrees C).
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F (0 to 50 degrees C).
- 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 (1 m).

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.

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- 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.

2.7 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.

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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 (0 to 50 degrees C).
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.

2.8 SYSTEM SOFTWARE

A Operating System:

1. Concurrent, multi-tasking capability.
 - a. Common Software Applications Supported: Microsoft Excel.
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) Chillers.
 - 2) Boilers.
 - 3) Air Handlers.
 - 4) Terminal HVAC Units.
 - 5) Fan Coil Units.
 - b. Ancillary Equipment

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- 1) Fans.
- 2) Pumps.
- 3) Coils.
- 4) Dampers.

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) Network connections.
 - 3) Building management panels.
 - 4) 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.

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- 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.

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- 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.

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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.

2.9 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.

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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.
- 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.
- 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 or as specified on drawings.
- 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.

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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.

2.10 CHILLER CONTROL PROGRAMS

- A Chilled Water Reset: Automatically reset controlled chilled water temperature satisfying cooling coil requiring greatest cooling.
- B Chiller Sequencing: Determine which combination of chillers will most efficiently satisfy chilled water load, by cycling chillers, based on comparing load to switchover limits defined for each chiller.

PART 3 EXECUTION

3.1 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.

3.2 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.

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- 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.

3.3 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 basic operator training 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.

3.4 DEMONSTRATION AND INSTRUCTIONS

- A Demonstrate complete and operating system to Owner.

3.5 MAINTENANCE

- A Provide service and maintenance of energy management and control systems for one years from Date of Substantial Completion.
- B Provide complete service of systems, including call backs. Make minimum of 2 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

MONITORING BASED COMISSIONING PLAN POINTS



FST DESIRED POINTS LIST					
EQUIPMENT	POINT	QTY	TREND	CALCULATION	DEVIATION ALARM
GLOBAL	OUTSIDE AIR TEMPERATURE	1	X		
	OUTSIDE AIR RELATIVE HUMIDITY	1	X		
	OUTSIDE AIR TEMPERATURE WET BULB	1	X		
	OUTSIDE AIR ENTHALPY	1	X	X	
	BUILDING PRESSURIZATION	12	X		X
	APPROXIMATE NUMBER OF POINTS	16			
CHILLED WATER SYSTEM (CHWS)	SYSTEM ENABLED COMMAND	1	X		
	CHW SUPPLY TEMPERATURE SETPOINT	1	X		
	TOTAL CHILLED WATER SUPPLY FLOW SWITCH	1	X		X
	TOTAL CHILLED WATER SUPPLY TEMPERATURE	2	X	X	
	CHILLED WATER SUPPLY/ RETURN FLOW RATE	2	X	X	
	CHILLED WATER SUPPLY/ RETURN FLOW RATE SETPOINT	2	X		
	CHILLED WATER SUPPLY/ RETURN TEMPERATURE	2	X		X
	PLANT CHILLED WATER SUPPLY/ RETURN FLOW RATE	1	X		X
	PLANT CHILLED WATER SUPPLY/ RETURN TEMPERATURE	2	X		X
	BUILDING CHILLED WATER DIFFERENTIAL PRESSURE	2	X		X
	BUILDING CHILLED WATER DIFFERENTIAL PRESSURE SETPOINT	2	X		
	BUILDING CHILLED WATER SUPPLY/ RETURN PRESSURE	2	X		X
	BUILDING CHILLED WATER SUPPLY/ RETURN TEMPERATURE	1	X		X
	BTU METER HOT WATER SUPPLY/ RETURN TEMPERATURE	1	X		X
	BTU METER HOT WATER SUPPLY/ RETURN FLOW RATE	1	X		X
	BTU METER ENERGY FLOW RATE	1	X	X	
	APPROXIMATE NUMBER OF POINTS PER SYSTEM	24			
CHWS CHILLER (CH) TYPICAL OF (4)	ENTERING/LEAVING CHILLED WATER TEMPERATURE	2	X	X	X
	CHILLER COMMAND (START/STOP)	1	X		X
	CHILLER STATUS	1	X		X
	CHILLER ISOLATION VALVE	1	X		
	CHILLED WATER FLOW RATE	1	X	X	
	CHILLER POWER	1	X		
	CHILLER PART LOAD FRACTION	1	X		
	EVAPORATOR INLET TEMP	1	X		X
	EVAPORATOR OUTLET TEMP	1	X		X
	CONDENSER INLET TEMP	1	X		X
	CONDENSER OUTLET TEMP	1	X		X
	EVAPORATOR FLOW	1	X		
	CONDENSER FLOW	1	X		
	EVAPORATOR REFRIGERANT PRESSURE	1	X		X
	EVAPORATOR REFRIGERANT TEMP	1	X		X
	CONDENSER REFRIGERANT PRESSURE	1	X		X
	CONDENSER REFRIGERANT TEMP	1	X		X
	APPROXIMATE NUMBER OF POINTS PER CHILLER	18			
CHWS/HRWS HEAT EXCHANGER (HX) TYPICAL OF (2)	HX ENTERING CHILLED WATER TEMPERATURE	1	X		X
	HX LEAVING CHILLED WATER TEMPERATURE	1	X		X
	HX ENTERING CHILLED WATER TEMPERATURE	1	X		X
	HX LEAVING CHILLED WATER TEMPERATURE	1	X		X
	HX ISOLATION VALVE	2	X		
	APPROXIMATE NUMBER OF POINTS PER HEAT EXCHANGER	6			
CHWS PRIMARY PUMP (CHWP) TYPICAL OF (7)	PUMP STATUS	1	X		X
	VFD START/STOP	1	X		X
	VFD SPEED CONTROL COMMAND/FEEDBACK	1	X	X	X
	VFD MOTOR POWER	1	X		
	APPROXIMATE NUMBER OF POINTS PER PUMP	4			
CHWS SECONDARY PUMP (CHWP) TYPICAL OF (2)	PUMP STATUS	1	X		X
	VFD START/STOP	1	X		X
	VFD SPEED CONTROL COMMAND/FEEDBACK	1	X	X	X
	VFD MOTOR POWER	1	X		
	APPROXIMATE NUMBER OF POINTS PER PUMP	4			
HEAT RECOVERY WATER SYSTEM (HRWS)	SYSTEM ENABLED COMMAND	1	X		
	CHW SUPPLY TEMPERATURE SETPOINT	1	X		
	BTU METER HOT WATER RETURN TEMPERATURE	2	X		X
	BTU METER HOT WATER SUPPLY TEMPERATURE	2	X		X
	BTU METER HOT WATER SUPPLY FLOW RATE	2	X	X	
	BTU METER ENERGY FLOW RATE	2	X	X	
	APPROXIMATE NUMBER OF POINTS PER SYSTEM	10			

FST DESIRED POINTS LIST					
EQUIPMENT	POINT	QTY	TREND	CALCULATION	DEVIATION ALARM
HRWS CHILLER (CH) TYPICAL OF (3)	ENTERING/LEAVING HEATING WATER TEMPERATURE	2	X	X	X
	CHILLER COMMAND (START/STOP)	1	X		X
	CHILLER STATUS	1	X		X
	HEATING WATER ISOLATION VALVE	1	X		
	HEATING WATER FLOW RATE	1	X		X
	CHILLER POWER	1	X		
	CHILLER PART LOAD FRACTION	1	X		
	EVAPORATOR INLET TEMP	1	X		
	EVAPORATOR OUTLET TEMP	1	X		
	CONDENSER INLET TEMP	1	X		X
	CONDENSER OUTLET TEMP	1	X		X
	EVAPORATOR FLOW	1	X		
	CONDENSER FLOW	1	X		
	EVAPORATOR REFRIGERANT PRESSURE	1	X		X
	EVAPORATOR REFRIGERANT TEMP	1	X		X
	CONDENSER REFRIGERANT PRESSURE	1	X		X
	CONDENSER REFRIGERANT TEMP	1	X		X
	APPROXIMATE NUMBER OF POINTS PER CHILLER	18			
HRWS PUMP (HRWP) TYPICAL OF (2)	PUMP STATUS	1	X		X
	VFD START/STOP	1	X		X
	VFD SPEED CONTROL COMMAND/FEEDBACK	2	X	X	X
	VFD MOTOR POWER	1	X		
	APPROXIMATE NUMBER OF POINTS PER PUMP	5			
HEATING HOT WATER SYSTEM (HHWS)	SYSTEM ENABLED COMMAND	1	X		
	BOILER EMERGENCY SHUTDOWN SWITCH	1	X		
	BTU METER ENERGY FLOW RATE	1	X	X	
	BTU METER HOT WATER SUPPLY/RETURN TEMPERATURE	2	X		X
	BTU METER HOT WATER SUPPLY FLOW RATE	1	X	X	
	BUILDING HOT WATER SUPPLY/RETURN TEMPERATURE	2	X		X
	BUILDING HOT WATER DIFFERENTIAL PRESSURE	1	X		X
	BUILDING HOT WATER SUPPLY/RETURN FLOW RATE	2	X	X	
	BUILDING HOT WATER SUPPLY/RETURN PRESSURE	2	X		X
	HOT WATER SUPPLY TEMPERATURE SETPOINT	1	X		X
	PLANT HOT WATER SUPPLY/RETURN TEMPERATURE	2	X		X
	PLANT HOT WATER SUPPLY/RETURN FLOW RATE	2	X	X	
	TOTAL HOT WATER SUPPLY FLOW SWITCH	1	X	X	
	TOTAL HOT WATER SUPPLY TEMPERATURE	1	X	X	
	APPROXIMATE NUMBER OF POINTS PER SYSTEM	20			
HHWS BOILER (B) TYPICAL OF (5)	BOILER COMMAND	1	X		X
	BOILER FIRING RATE	1	X		
	BOILER STATUS	1	X		X
	HOT WATER SUPPLY/RETURN TEMPERATURE	2	X		X
	HOT WATER SUPPLY FLOW SWITCH	1	X		
	APPROXIMATE NUMBER OF POINTS PER PUMP	6			
HHWS PRIMARY PUMP (PHWP) TYPICAL OF (5)	COMMAND (START / STOP)	1	X		X
	PUMP STATUS	1	X		X
	DIFFERENTIAL PRESSURE	1	X	X	X
	APPROXIMATE NUMBER OF POINTS PER PUMP	3			
HHWS SECONDARY PUMP (SHWP) TYPICAL OF (3)	PUMP STATUS	1	X		X
	VFD START/STOP	1	X		X
	VFD SPEED CONTROL COMMAND/FEEDBACK	2	X	X	X
	VFD MOTOR POWER	1	X		
	APPROXIMATE NUMBER OF POINTS PER PUMP	5			
REVERSE OSMOSIS WATER (RO) TYPICAL OF (1)	STATUS	1	X		X
	ON/OFF	1	X		X
	PERCENT CAPACITY	1	X		
	APPROXIMATE NUMBER OF POINTS PER PUMP	3			

FST DESIRED POINTS LIST					
EQUIPMENT	POINT	QTY	TREND	CALCULATION	DEVIATION ALARM
VARIABLE VOLUME AHU WITH ENTHALPY WHEEL TYPICAL OF (4)	BUILDING INTERIOR/EXTERIOR STATIC PRESSURE	2	X		
	CHILLED WATER SUPPLY/RETURN TEMPERATURE	2	X		X
	CHILLED/HEATING WATER CONTROL VALVE COMMAND/FEEDBACK	2	X	X	X
	ECONOMIZER OUTSIDE AIR DAMPER	1	X		
	EXHAUST AIR DUCT STATIC PRESSURE	1	X		
	HEAT WHEEL DIFFERENTIAL PRESSURE	1	X		
	HEAT WHEEL MOTOR POWER	1	X		X
	HEAT WHEEL MOTOR STATUS	1	X		X
	HEAT WHEEL SUPPLY/EXHAUST AIR HUMIDITY	2	X		X
	HEAT WHEEL SUPPLY/EXHAUST AIR TEMPERATURE	2	X		X
	HEAT WHEEL VFD SPEED CONTROL/FEEDBACK	2	X	X	X
	HEAT WHEEL VFD START / STOP	1	X		X
	HEAT WHEEL VFD STATUS	1	X		X
	HEAT WHEEL OUTSIDE/EXHAUST AIR BYPASS DAMPER	2	X		X
	HEATING WATER SUPPLY/RETURN TEMPERATURE	2	X	X	X
	MINIMUM OUTSIDE AIR DAMPER	1	X		
	MIXED AIR TEMPERATURE	1	X		X
	SA FILTER DIFFERENTIAL PRESSURE	1	X		
	OA FILTER DIFFERENTIAL PRESSURE	1	X		
	RA FILTER DIFFERENTIAL PRESSURE	1	X		
	EA FILTER DIFFERENTIAL PRESSURE	1	X		
	RELIEF AIR DAMPER	1	X		
	RETURN AIR DAMPER	1	X		
	RETURN AIR FAN MOTOR POWER	4	X		X
	RETURN AIR FAN MOTOR STATUS	4	X		X
	RETURN AIR FAN VFD SPEED CONTROL/FEEDBACK	8	X	X	X
	RETURN AIR FAN VFD START / STOP	4	X		X
	RETURN AIR FAN VFD STATUS	4	X		X
	RETURN AIR HUMIDITY	1	X		
	SUPPLY AIR DUCT STATIC PRESSURE	1	X		
	SUPPLY AIR FAN MOTOR POWER	4	X		
	SUPPLY AIR FAN MOTOR STATUS	4	X		X
	SUPPLY AIR FAN VFD SPEED CONTROL	4	X		
	SUPPLY AIR FAN VFD START / STOP	4	X		X
	SUPPLY AIR FAN VFD STATUS	4	X		X
	SUPPLY/OUTSIDE AIR FLOW MEASURING STATION	2	X	X	X
	SUPPLY/RETURN FAN INLET DAMPER	8	X		
	SUPPLY/RETURN/MIXED AIR TEMPERATURE	3	X		X
	APPROXIMATE NUMBER OF POINTS PER UNIT	90			
CABNIT UNIT HEATER (CUH) TYPICAL OF (6)	SUPPLY FAN MOTOR STATUS	1	X		X
	SUPPLY FAN STARTER	1	X		X
	HEATING CONTROL VALVE COMMAND/FEEDBACK	1	X	X	X
	SPACE TEMPERATURE	1	X		X
	SPACE TEMPERATURE SETPOINT	1	X		
FAN COIL UNIT (FCU) TYPICAL OF (78)	APPROXIMATE NUMBER OF POINTS PER UNIT	5			
	SPACE TEMPERATURE	1	X		X
	SPACE TEMPERATURE SETPOINT	1	X		
	SUPPLY FAN STATUS	1	X		X
	SUPPLY FAN STARTER	1	X		X
	COOLING COIL CONTROL VALVE COMMAND/FEEDBACK	1	X	X	X
	SPACE OCCUPANCY SENSOR	1	X		
	DRAIN PAN LEVEL SWITCH	1	X		
	RADIANT CONTROL VALVE COMMAND/FEEDBACK	1	X	X	X
	HEATING COIL CONTROL VALVE COMMAND/FEEDBACK	1	X	X	X
	SUPPLY AIR TEMPERATURE	1	X		X
	SUPPLY AIR TEMPERATURE SETPOINT	1	X		
	APPROXIMATE NUMBER OF POINTS PER UNIT	11			
WALL HUNG AC UNIT (AC)	SPACE TEMPERATURE	1	X		X
	SPACE TEMPERATURE SETPOINT	1	X		
	SUPPLY FAN MOTOR STATUS	1	X		X
	SUPPLY FAN STARTER	1	X		X
	DRAIN PAN LEVEL SWITCH	1	X		
	APPROXIMATE NUMBER OF POINTS PER UNIT	5			
SAV/EAV/VAV BOX TYPICAL OF (466)	SPACE TEMPERATURE	1	X		X
	SPACE TEMPERATURE SETPOINT	1	X		
	SUPPLY AIR FLOW MEASURING STATION	1	X		
	TERMINAL UNIT DAMPER	1	X		
	REHEAT COIL CONTROL VALVE COMMAND/FEEDBACK	1	X		X
	SPACE OCCUPANCY SENSOR	1	X		
	SUPPLY AIR TEMPERATURE	1	X		X
	SUPPLY AIR TEMPERATURE SETPOINT	1	X		
	HUMIDITY SENSOR	1	X	X	X
	HUMIDITY SETPOINT	1	X		
	CARBON DIOXIDE SENSOR	1	X	X	X
	CARBON DIOXIDE SETPOINT	1	X		
	APPROXIMATE NUMBER OF POINTS PER UNIT	12			

FST DESIRED POINTS LIST					
EQUIPMENT	POINT	QTY	TREND	CALCULATION	DEVIATION ALARM
EXHAUST FAN TYPICAL OF (6)	EXHAUST AIR FAN MOTOR STATUS	2	X		X
	EXHAUST AIR FAN VFD SPEED CONTROL/FEEDBACK	4	X		X
	EXHAUST AIR FAN VFD START / STOP	2	X		X
	EXHAUST AIR FAN VFD STATUS	2	X		
	EXHAUST AIR FAN MOTOR POWER	2	X		
	EXHAUST STATIC PRESSURE	2	X		
	BYPASS AIR DAMPER	1	X		
	ISOLATION DAMPER	2	X		
	EXHAUST AIR DUCT STATIC PRESSURE	9	X		
	APPROXIMATE NUMBER OF POINTS PER UNIT	38			
AIR CURTAIN (AC) TYPICAL OF (3)	SUPPLY FAN MOTOR STATUS	1	X		X
	SUPPLY FAN STARTER	1	X		X
	HEATING CONTROL VALVE COMMAND/FEEDBACK	2	X		X
	SPACE TEMPERATURE	1	X		X
	SPACE TEMPERATURE SETPOINT	1	X		
	APPROXIMATE NUMBER OF POINTS PER UNIT	6			
SUPPLY FAN (SF) TYPICAL OF (2)	SPACE TEMPERATURE	1	X		X
	SPACE TEMPERATURE SETPOINT	1	X		
	SUPPLY FAN MOTOR STATUS	1	X		X
	SUPPLY FAN STARTER	1	X		
	SUPPLY AIR DAMPER	1	X		
	RELIEF AIR DAMPER	1	X		
	APPROXIMATE NUMBER OF POINTS PER UNIT	6			

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SECTION 230934
VARIABLE-FREQUENCY MOTOR CONTROLLERS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Variable-frequency motor controllers for low-voltage (600 V and less) AC motor applications.

1.2 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.

1.3 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 IA 10030 - Industrial Control and Systems: Enclosures; 2024.
- D NEMA IS 10033 - Adjustable Speed Drives; 2020 (Reapproved 2025).
- E NEMA IS 10034 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems; 2022 (Reapproved 2025).
- F NEMA ICS 7.2 - Application Guide for AC Adjustable Speed Drive Systems; 2021.
- G 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; 2005.

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- H NEMA MG 00001 - Motors and Generators; 2024.
- I NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems; 2021.
- J NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- K UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.
- L 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.

1.4 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.

1.5 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.
- B Shop Drawings: Indicate dimensions, voltage, controller sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
- C Field quality control test reports.
- D Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

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- E Warranty: Submit documentation of final executed warranty.
- F Project Record Documents: Record actual installed locations of controllers and final equipment settings.

1.6 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

1.7 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.

1.8 WARRANTY

- A See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B Provide manufacturer warranty covering repair or replacement due to defective materials or workmanship within one (1) year of the warranty start date.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. ABB.
 - 2. Allen Bradley.
 - 3. Danfoss.
 - 4. Eaton.
 - 5. Reliance Electric
 - 6. Yaskawa America, Inc.
- B Source Limitations: Furnish variable-frequency motor controllers and associated components produced by a single manufacturer.

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2.2 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 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.
- D Provide controllers selected for actual installed motors and coupled mechanical loads in accordance with NEMA ICS 7.2, 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.
- E Devices on Load Side of Controller: Suitable for application across full controller output frequency range.
- F 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.
- G Power Conversion System: Microprocessor-based, pulse width modulation type.
 - 1. Diode-based, 6-pulse type unless otherwise indicated.
- H 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.

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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.
 - h. Automatic response to loss of speed reference; selectable to run motor at last known speed, run motor at designated speed, or stop motor.
 - i. PID Control: Provide integral PID controller employing feedback for closed-loop control where indicated or required.
 - j. Selectable frequency-skipping; minimum of three independently adjustable bands.
 - k. Automatic catching of rotating motor.
 - l. Safety Interlock: Provide permissive run safety interlock capability where indicated or required; upon activation of designated input, stop and prevent operation of motor; operational in both drive and bypass modes where applicable.
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. Speed reference.
 - j. Instantaneous power.
 - k. Elapsed run time.
5. Protective Functions/Alarm Indications:
 - a. Overcurrent.
 - b. Motor overload.
 - c. Undervoltage.
 - d. Overvoltage.
 - e. Controller overtemperature.
 - f. Input/output phase loss.

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- g. Output short circuit protection.
 - h. Output ground fault protection.
 - 6. Inputs:
 - a. Digital Input(s): Three.
 - b. Analog Input(s): Two.
 - 7. Outputs:
 - a. Analog Output(s): One.
 - b. Relay Output(s): Two.
 - 8. Communications: BACnet communication interface compatible with connected systems. Provide accessories necessary for proper interface.
 - 9. Features:
 - a. Password-protected security access.
 - b. Event log.
- I Power Conditioning/Filtering:
 - 1. Provide power conditioning features specified below for each controller unless otherwise indicated or required.
 - a. Drives 10HP and under: DC link choke.
 - b. Drives over 10HP and under 50HP: DC link choke and 5% input/line reactor.
 - c. Drives 50HP and over: DC link choke and RC tuned passive filter.
 - 2. Long Motor Leads:
 - a. Motor Leads Over 300 Feet (90 m): Provide output dV/dt filter.
- J Packaged Controllers: Controllers factory-mounted in separate enclosure with externally operable disconnect and specified accessories.
 - 1. Disconnects: Circuit breaker type.
 - a. 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.
 - b. Provide auxiliary interlock for disconnection of external control power sources where applicable.
 - 2. Provide door-mounted remote operator interface.
- K Service Conditions:
 - 1. Provide controllers and associated components suitable for operation under following service conditions without derating:
 - a. Altitude: Less than 3,300 feet (1,000 m).
 - b. Ambient Temperature: Between 32 degrees F (0 degrees C) and 104 degrees F (40 degrees C).
 - 2. Provide controllers and associated components suitable for operation at indicated ratings under service conditions at installed location.
- L Short Circuit Current Rating:
 - 1. Provide controllers with listed short circuit current rating of 65 kAIC.

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2. Provide line/input reactors where specified by manufacturer for required short circuit current rating.

M Conductor Terminations: Suitable for use with conductors to be installed.

N 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. Indoor Clean, Dry Locations: Type 1 or Type 12.
3. Finish: Manufacturer's standard unless otherwise indicated.
4. Enclosure Ventilation: Forced air or natural convection as required to meet equipment service conditions.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated and all clearances will be met.
- 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.

3.2 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.

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- F Install controllers plumb and level.
- G Unless indicated otherwise on drawings, smaller size controllers shall be mounted on unistrut frames secured to the floor, independent of equipment. Larger units designed for floor mounting shall be mounted on 4 inch concrete housekeeping pads.
- H Provide grounding and bonding in accordance with Section 260526.
- I Install field-installed devices, components, and accessories.
- J Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.
- K Set field-adjustable settings of controllers and associated components according to installed motor requirements, in accordance with recommendations of manufacturers of controller and load.
- L Identify controllers in accordance with Section 230553.

3.3 FIELD QUALITY CONTROL

- A Provide services of manufacturer's authorized representative to perform inspection and testing. Include manufacturer's reports with submittals.
- 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 Correct deficiencies and replace damaged or defective controllers or associated components.

3.4 ADJUSTING

- A Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B Adjust drive parameters to accommodate motor and equipment operation.
- C For drives on emergency power, adjust any required filtering for proper operation.

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3.5 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.

3.6 CLOSEOUT ACTIVITIES

- A Demonstration: Demonstrate proper operation of controllers to Owner, and correct deficiencies or make adjustments as directed.
- B 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. Instructor: Manufacturer's authorized representative.

3.7 PROTECTION

- A Protect installed controllers from subsequent construction operations.

END OF SECTION 230934

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SECTION 232113
HYDRONIC PIPING

PART 1 GENERAL

1.1 SECTION INCLUDES

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

1.2 RELATED REQUIREMENTS

- A Section 230516 - Expansion Fittings and Loops for HVAC Piping.
- B Section 230523 - General-Duty Valves for HVAC Piping.
- C Section 230548 - Vibration Controls for HVAC.
- D Section 230553 - Identification for HVAC Piping and Equipment.
- E Section 230719 - HVAC Piping and Equipment Insulation.
- F Section 232114 - Hydronic Specialties.

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G Section 232500 - HVAC Water Treatment: Pipe cleaning.

1.3 REFERENCE STANDARDS

- 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.
- 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; 2020.
- E ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2022.
- F ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- G ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2023a.
- H ASTM B32 - Standard Specification for Solder Metal; 2020.
- 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 F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 2024.
- L AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2019.
- M AWS D10.12M/D10.12 - Guide for Welding Mild Steel Pipe; 2000.
- N MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2018, with Amendment (2019).

1.4 SUBMITTALS

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- A Product Data:
 - 1. Include data on pipe materials, pipe fittings, valves, and accessories.
 - 2. Show grooved joint couplings, fittings, valves, and specialties on drawings and product submittals, specifically identified with the manufacturer's style or series designation.

- B Shop Drawings (For information only, not a reviewed submittal): Detail the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
 - 1. BIM coordination with all other disciplines.

1.5 QUALITY ASSURANCE

- A Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.
 - 1. A factory trained representative (direct employee) of the coupling manufacturer shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation.
 - 2. The representative shall periodically visit the job site and review installation to ensure best practices in grooved joint installation are being followed.
 - 3. Contractor shall remove and replace any improperly installed products.

- B Date stamp all castings used for coupling housings, fittings, valve bodies, etc. for quality assurance and traceability.

- C Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.6 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

2.1 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:

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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. 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 or unions to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
- D Provide the following:
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 (20 mm) gate valves with cap; pipe to nearest floor drain.
- E Welding Materials and Procedures: Comply with ASME BPVC-IX.

2.2 HEATING WATER AND CHILLED WATER PIPING, ABOVE GRADE

- A NPS 2 and smaller shall be copper tube. NPS 2-1/2 and larger shall be steel or copper tube.
- B Steel Pipe: ASTM A53/A53M, Schedule 40, black steel with plain ends; welded and seamless, Grade B, using one of the following joint types:
1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D10.12M/D10.12 welded.
- C 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.
 - b. Braze: AWS A5.8M/A5.8 BCuP copper/silver alloy.
 2. Mechanical Press sealed fittings: Double pressed type, NSF 61 and NSF 372 approved or certified, utilizing EPDM, nontoxic, synthetic rubber sealing elements.
 3. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.

2.3 CONDENSATE AND EQUIPMENT DRAINS AND OVERFLOWS

- A 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.

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2. Mechanical Press sealed fittings: Double pressed type, NSF 61 and NSF 372 approved or certified, utilizing EPDM, nontoxic, synthetic rubber sealing elements.
 - a. AHU condensate within mechanical room.
- B Special Applications:
1. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
 2. Air-Vent Piping:
 - a. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 - b. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
 3. Safety-Valve-Inlet and -Outlet Piping for Hot Water and Chilled Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

2.4 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 (13 to 38 mm): Malleable iron, adjustable swivel, split ring.
 3. Hangers for Hot Pipe Sizes 2 to 4 Inches (50 to 100 mm): Carbon steel, adjustable, clevis.
 4. Hangers for Hot Pipe Sizes 6 Inches (150 mm) and Greater: Adjustable steel yoke, cast iron roll, double hanger.
 5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches (150 mm) and Greater: Steel channels with welded spacers and hanger rods, cast iron roll.
 7. Wall Support for Pipe Sizes to 3 Inches (76 mm): Cast iron hook.
 8. Wall Support for Pipe Sizes 4 Inches (100 mm) and Greater: Welded steel bracket and wrought steel clamp.
 9. Vertical Support: Steel riser clamp.
 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 Rooftop Supports: 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:
1. Bases: High-density polypropylene.
 2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.

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3. Steel Components: Stainless steel or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion-resistant material.
5. Height: Provide minimum clearance of 6 inches (150 mm) under pipe to top of roofing.

2.5 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

- A Unions for Pipe of 2 Inches (50 mm, DN) and Less:
1. Ferrous Piping: 150 psi (1034 kPa) brass or malleable iron, threaded.
 2. Copper Pipe: Bronze, soldered joints.
- B Flanges for Pipe 2 Inches (50 mm, DN) and Greater:
1. Ferrous Piping: 150 psig (1034 kPa) forged steel, slip-on.
 2. Copper Piping: Bronze.
 3. Gaskets: 1/16 inch (1.6 mm) thick, preformed neoprene.
- C Dielectric Connections:
1. Waterways:
 - a. Construct of galvanized steel with threaded end connections to match connecting piping.
 - b. Suitable for the required operating pressures and temperatures.
 2. Flanges:
 - a. Construct of galvanized steel with threaded end connections to match connecting piping.
 - b. Suitable for the required operating pressures and temperatures.
 3. Unions:
 - a. Service: 250 psi (1,723.6 kPa), minus 20 to 180 deg F (minus 28.9 to 82.2 deg F).

2.6 BALL VALVES

- A Manufacturers:
1. Anvil International: www.anvilintl.com/#sle.
 2. Apollo Valves: www.apollovalves.com/#sle.
 3. Grinnell Products: www.grinnell.com/#sle.
- B Up To and Including 2 Inches (50 mm):
1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.

2.7 BUTTERFLY VALVES

- A Manufacturers:

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1. Anvil International: www.anvilintl.com/#sle.
2. Apollo Valves: www.apollovalves.com/#sle.
3. Grinnell Products: www.grinnell.com/#sle.

B Body: Cast or ductile iron with resilient replaceable EPDM seat, lug ends, extended neck.

C Disc: Construct of aluminum bronze, chrome plated ductile iron, stainless steel, or ductile iron with EPDM encapsulation.

D Operator: 10 position lever handle.

2.8 SWING CHECK VALVES

A Manufacturers:

1. Anvil International: www.anvilintl.com/#sle.
2. Apollo Valves: www.apollovalves.com/#sle.
3. Grinnell Products: www.grinnell.com/#sle.

B Up To and Including 2 Inches (50 mm):

1. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder ends.

C Over 2 Inches (50 mm):

1. Iron body, bronze trim, stainless steel, bronze, or bronze faced rotating swing disc, renewable disc and seat, flanged ends.

2.9 FLOW CONTROLS

A Manufacturers:

1. Anvil International: www.anvilintl.com/#sle.
2. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/#sle.
3. Griswold Controls: www.griswoldcontrols.com/#sle.
4. ITT Bell & Gossett: www.bellgossett.com/#sle.
5. Taco, Inc: www.taco-hvac.com/#sle.

B Construction: Class 125, Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.

C 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 (13.7 kPa).

PART 3 EXECUTION

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3.1 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 using jointing system specified.
- D Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- E After completion, fill, clean, and treat systems. See Section 232500 for additional requirements.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- C Install heating water, glycol, chilled water, and condenser water piping to ASME B31.9 requirements.
- D Route piping in orderly manner, parallel to building structure, and maintain gradient.
- E Install piping to conserve building space and to avoid interference with use of space.
- F Group piping whenever practical at common elevations.
- G Sleeve pipe passing through partitions, walls, and floors.
- H Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified or those acceptable to authority having jurisdiction.
- I Slope piping and arrange to drain at low points.

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- J Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. See Section 230516.
 - 1. Flexible couplings may be used in header piping to accommodate thermal growth, thermal contraction in lieu of expansion loops.
 - 2. Use flexible couplings in expansion loops.

3.3 JOINT CONSTRUCTION

- A Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- B Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- C Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads 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.
- D Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.
- E Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- F 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.
 - 3. Assemble joints with coupling and gasket, lubricant, and bolts.
 - 4. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness.
 - 5. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
- G Pressure-Seal Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.
- H Inserts:
 - 1. Provide inserts for placement in concrete formwork.

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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 (100 mm).
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.

I 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 (13 mm) space between finished covering and adjacent work.
4. Place hangers within 12 inches (300 mm) of each horizontal elbow.
5. Use hangers with 1-1/2 inches (38 mm) 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.

J Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. See Section 230719.

K Provide access where valves and fittings are not exposed.

L Use eccentric reducers to maintain top of pipe level.

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.

3.4 HANGERS AND SUPPORTS

A Install hangers for piping, with maximum horizontal spacing and minimum rod diameters, and support vertical runs to comply with MSS SP-58, manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

B Support horizontal piping within 12 inches of each fitting and coupling.

C Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

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D Hanger Spacing for Copper Tubing.

1. 1/2 Inch (15 mm) and 3/4 inch (20 mm): Maximum span, 5 feet (1500 mm); minimum rod size, 1/4 inch (6 mm).
2. 1 Inch (25 mm): Maximum span, 6 feet (1800 mm); minimum rod size, 1/4 inch (6 mm).
3. 1-1/2 Inches (40 mm) and 2 Inches (50 mm): Maximum span, 8 feet (2400 mm); minimum rod size, 3/8 inch (9 mm).
4. 2-1/2 Inches (65 mm): Maximum span, 9 feet (2700 mm); minimum rod size, 3/8 inch (9 mm).
5. 3 Inches (80 mm) and larger: Maximum span, 10 feet (3.0 m); minimum rod size, 3/8 inch (9 mm).
6. 4 Inches (100 mm): Maximum span, 12 feet (3.6 m); minimum rod size, 1/2 inch (13 mm).

E Hanger Spacing for Steel Piping.

1. 1/2 Inch (15 mm), 3/4 Inch (20 mm), and 1 Inch (25 mm): Maximum span, 7 feet (2100 mm); minimum rod size, 1/4 inch (6 mm).
2. 1-1/4 Inches (32 mm): Maximum span, 8 feet (2400 mm); minimum rod size, 3/8 inch (9 mm).
3. 1-1/2 Inches (40 mm): Maximum span, 9 feet (2700 mm); minimum rod size, 3/8 inch (9 mm).
4. 2 Inches (50 mm): Maximum span, 10 feet (3.0 m); minimum rod size, 3/8 inch (9 mm).
5. 2-1/2 Inches (65 mm): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9 mm).
6. 3 Inches (80 mm): Maximum span, 12 feet (3.6 m); minimum rod size, 3/8 inch (9 mm).
7. 4 Inches (100 mm): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).
8. 6 Inches (150 mm) and larger: Maximum span, 16 feet (4.9 m); minimum rod size, 1/2 inch (13 mm).

F Hanger Spacing for Plastic Piping: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

3.5 FIELD QUALITY CONTROL

A Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

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- B Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.

END OF SECTION 232113

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SECTION 232114
HYDRONIC SPECIALTIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Expansion tanks.
- B Air vents.
- C Air separators.
- D Strainers.
- E Suction diffusers.
- F Flexible connectors.
- G Combination pump discharge valves.
- H Balancing valves.
- I Flow meters.
- J Relief valves.
- K Glycol system.

1.2 RELATED REQUIREMENTS

- A Section 232113 - Hydronic Piping.
- B Section 232500 - HVAC Water Treatment: Pipe cleaning.

1.3 REFERENCE STANDARDS

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- A ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2023.

1.4 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.

1.5 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

2.1 EXPANSION TANKS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Amtrol Inc
 - 2. Armstrong International, Inc.
 - 3. Bell & Gossett, a brand of Xylem, Inc
 - 4. Taco, Inc
 - 5. Wessels.
- B Maximum Rated Working Pressure: 125 psi (860 kPa).
- C Maximum Allowable Service Temperature: 240 degrees F (115.6 degrees C).
- D Construction: Welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; supplied with National Board Form U-1, adjustable flexible EPDM diaphragm or bladder seal factory precharged to 12 psi (80 kPa).

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- E Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check backflow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.
- F Accessories: Provide air-charging fitting, pressure gauge, and tank drain ball valve.

2.2 AIR VENTS

- A Manufacturers:
 - 1. Amtrol, Inc.
 - 2. Armstrong International, Inc.
 - 3. Bell & Gossett, a brand of Xylem, Inc.
 - 4. Taco, Inc.
- B Manual Air Vent: Short vertical sections of 3/4-inch diameter pipe to form air chamber, with 1/8 inch (6 mm, DN) brass needle valve at top of chamber.
- C Automatic (Float-Style) 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 Maximum Fluid Pressure: 150 psi (1,034 kPa).
- E Maximum Fluid Temperature: 250 degrees F (121.1 degrees C).

2.3 AIR SEPARATORS

- A Coalescing Air/Dirt Separators:
 - 1. Manufacturers:
 - a. Armstrong International, Inc
 - b. Bell & Gossett, a brand of Xylem, Inc
 - c. Spirotherm, Inc
 - 2. Tank: Fabricated steel tank; tested and stamped in accordance with ASME BPVC-VIII-1 for maximum fluid service subject to application requirements and manufacturer's standard maximum operating conditions.
 - 3. Coalescing Medium: Provide structured copper or stainless steel medium filling the entire vessel to suppress turbulence and provide air elimination efficiency of 100 percent free air, 100 percent entrained air, and 99.6 percent dissolved air at the installed location.
 - 4. Air Vent: Integral float actuated air vent at top fitting of tank rated at 150 psi (1,034 kPa), threaded to top of separator.
 - 5. End Connections: Class 150 flanged for 2-1/2 inch (65 mm, DN) and larger otherwise threaded.
 - 6. Blowdown Connection: Threaded.

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7. Size: Match system flow capacity.
8. Maximum Fluid Service Pressure: 150 psi (1,034 kPa).
9. Maximum Fluid Service Temperature: 250 degrees F (121.1 degrees C).

2.4 STRAINERS

- A Size 2 inch (50 mm, DN) and Under:
1. Provide sweat brass or iron body for up to 175 psi (1,200 kPa) working pressure, Y-pattern strainer with 1/32 inch (0.8 mm) stainless steel perforated screen.
- B Size 2-1/2 inch (65 mm, DN) to 12 inch (300 mm, DN):
1. Provide flanged iron body for up to 175 psi (1,200 kPa) working pressure, up to 250 degrees F (121.1 degrees C) working temperature, Y-pattern strainer with 1/16 inch (1.6 mm) or 3/64 inch (1.2 mm) stainless steel perforated screen.
- C Accessories: Provide outlet ball valve.

2.5 SUCTION DIFFUSERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Armstrong International, Inc.
 2. Bell & Gossett, a brand of Xylem, Inc.
 3. Taco, Inc.
- B Fitting: Angle pattern, cast-iron body, threaded for 2 inch (50 mm) and smaller, flanged for 2-1/2 inch (65 mm, DN) and larger, rated for 175 psi (1200 kPa) working pressure, with inlet vanes, cylinder strainer with 3/16 inch (5 mm) diameter openings, disposable 5/32 inch (4 mm) mesh strainer to fit over cylinder strainer, 20 mesh startup screen, and permanent magnet located in flow stream and removable for cleaning.
- C Class 125:
1. Horizontally or vertically mounted angle-pattern fitting with integral-cast vanes, fine particle mesh screen and magnetic drain plugs for particle removal without disassembly.
 2. Maximum Operating Service: 175 psi (1,200 kPa) and 250 degrees F (148.9 degrees C).
 3. Sizes, Material, and Connection:
 - a. 2 inch (50 mm, DN) and Smaller: Cast iron body, threaded.
 - b. 2-1/2 to 12 inch (65 to 300 mm, DN): Ductile iron body, flanged.
- D Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.6 FLEXIBLE CONNECTORS

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- A Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.
 - 1. Maximum Operating Service: 150 psi (1030 kPa) at 240 degrees F (115.6 degrees C).
 - 2. Performance: Capable of 3/4-inch misalignment.
 - 3. End Connections: Same as specified for pipe jointing.
 - 4. Provide necessary accessories.

2.7 COMBINATION PUMP DISCHARGE VALVES

- A Manufacturers:
 - 1. Armstrong International, Inc.
 - 2. Bell & Gossett, a brand of Xylem, Inc.
 - 3. Taco, Inc: www.
- B Class 125:
 - 1. Maximum Service Operation: 175 psi (1,200 kPa) at 125 degrees F (51.7 degrees C).
- C Quarter-Turn Plug Type: Flanged cast-iron body with bolt-on bonnet, position indicator, stainless steel stem, backflow preventer, memory stop, metering connectors, bubble-tight shutoff, and wrench-adjustable plug flow regulator.
- D Triple-Duty Globe Type: Grooved or flanged cast-iron angle pattern body with bolt-on bonnet, position indicator, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, metering connectors, flow shutoff mechanism, and adjustable flow handle.

2.8 BALANCING VALVES

- A Manufacturers: Subject to compliance with requirements, provide products from one of the following or an approved equal.
 - 1. Armstrong International, Inc.
 - 2. Bell & Gossett, a brand of Xylem, Inc.
 - 3. Griswold Controls
 - 4. IMI Flow Design
 - 5. Hays Fluid Controls
 - 6. Nexus Valve, Inc.
 - 7. Tour and Anderson
- B Size 2 inch (50 mm, DN) and Smaller:
 - 1. Provide ball or globe style with flow balancing, shut-off capabilities, memory stops, and minimum of two metering ports and NPT threaded, press, or soldered connections.
 - 2. Metal construction materials consist of bronze or brass.
 - 3. Non-metal construction materials consist of Teflon or EPDM.
 - 4. Maximum Service Operation: 255 psi at 240 degrees F (1,551 kPa at 115.6 degrees C).

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- C Size 2-1/2 inch (65 mm, DN) and Larger:
1. Provide ball, globe, or butterfly style with flow balancing, shut-off capabilities, memory stops, and minimum of two metering ports and flanged or grooved connections.
 2. Valve body construction materials consist of cast iron or ductile iron.
 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, or EPDM.
 4. Maximum Service Operation: 175 psi at 250 degrees F (1,200 kPa at 121.1 degrees C).

2.9 RELIEF VALVES

- A Manufacturers:
1. American Wheatley, a company of Global Flow Products, LLC
 2. Apollo Valves
 3. Armstrong International, Inc
 4. Bell & Gossett, a brand of Xylem, Inc
- B Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

2.10 GLYCOL SYSTEM

- A Pump System:
1. Storage: 50 gal (189.3 L) polypropylene tank with bolt-removable hinged solid cover and enamel coated carbon steel tank-stand.
 2. Pump:
 - a. Thermally protected 1/4 hp (0.2 kW) motor at 115 to 120 VAC, single phase rated for indoor service.
 - b. Maximum Service Operation: 100 psi (689 kPa) at 85 degrees F (29 degrees C).
 3. Mechanical Accessories: System isolation valves, strainer, and pressure gauges.
 4. Control Panel:
 - a. Fused single-point system connection rated at 115 to 120 VAC, single phase.
 - b. Interface: Hand switches with indicating lights for ON, FAULT, and LOW LEVEL.
 - c. Pressure Switch: Panel-mounted and prewired for 10 psi (69 kPa) cut-in and 40 psi (276 kPa) cut-out, adjustable.
 - d. Low Level Cut-Off Switch: Prewired to shut-down unit upon activation. Tank-side mounted.
 - e. Auxiliary Dry Contacts: Low level, high level, and fault/alarm for remote monitoring.
 5. Pressure Relief Valve: System-mounted brass valve tubed from pump discharge side into tank with adjustable setpoint between 20 psi (138 kPa) and 150 psi (1,034 kPa).
- B Glycol Solution:
1. Water-based solution mix containing 30 percent propylene glycol by volume required for cooling or heating system operating temperature range.
 2. Cooling or heating System Operating Temperature Range: Between freezing and boiling points of 3 and 220 degrees F (minus 16.1 and 104.4 degrees C) at 14.7 psia (101.4 kPa).

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PART 3 EXECUTION

3.1 INSTALLATION

- A Install specialties in accordance with manufacturer's instructions.
- B Provide manual air vents at system high points, at heat transfer coils, and elsewhere as required for system air venting.
- C Install automatic air vents in mechanical equipment rooms only. For automatic air vents in concealed locations, provide vent tubing to nearest drain.
- D Provide air separator on suction side of system circulation pump and connect to expansion tank.
 - 1. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
 - 2. Install drain valve on air separators NPS 2 and larger.
- E Install diaphragm- or bladder-type expansion tanks on the floor.
- F Vent and purge air from hydronic system, and ensure that expansion tank is properly charged with air to suit system Project requirements.
- G Provide valved drain and hose connection on strainer blowdown connection.
- H Provide suction diffuser on suction side of base-mounted centrifugal pumps. Remove temporary strainers after cleaning systems.
- I Provide combination pump discharge valve on discharge side of base mounted centrifugal pumps.
- J Support pump fittings with floor-mounted pipe and flange supports.
- K Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- L Balancing Valves:
 - 1. Install calibrated-orifice balancing valve at each branch connection to return main.
 - 2. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.

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- M Relief Valves:
1. Provide relief valves on pressure tanks, low-pressure side of reducing valves, heat exchangers, and expansion tanks.
 2. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.
 3. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
 4. Pipe relief valve outlet to nearest floor drain.
- N Where one line vents several relief valves, make cross-sectional area equal to sum of individual vent areas.
- O Clean and flush glycol system before adding glycol solution, see Section 232500.
- P Feed glycol solution to system through make-up line with pressure regulator, venting system high points. Set to fill at 12 psi (80 kPa).
- Q Perform tests determining strength of glycol and water solution and submit written test results.

END OF SECTION 232114

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SECTION 232123
HYDRONIC PUMPS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A In-line pumps.
- B End-suction pumps.

1.2 RELATED REQUIREMENTS

- A Section 033000 - Cast-in-Place Concrete.
- B Section 230513 - Common Motor Requirements for HVAC Equipment.
- C Section 230548 - Vibration Controls for HVAC.
- D Section 230923 - Direct-Digital Control System for HVAC.
- E Section 230934 - Variable-Frequency Motor Controllers for HVAC.
- F Section 232114 - Hydronic Specialties: Suction diffusers and multi-purpose valves.
- G Section 262913 - Enclosed Controllers.

1.3 REFERENCE STANDARDS

- A HI - Hydraulic Institute.
- 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.

1.4 SUBMITTALS

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- A 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.
- B Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
- C Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.5 DELIVERY, STORAGE, AND HANDLING

- A Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- B Storage: Store pumps in dry location. Retain protective covers for flanges and protective coatings during storage. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- C Comply with pump manufacturer's written rigging instructions.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Armstrong Fluid Technology, Inc
 - 2. Bell & Gossett, a Xylem Inc. brand
 - 3. Grundfos Pumps Corporation
- B Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

2.2 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 Minimum Quality Standard: UL 778.

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- C Pump motors shall be 1,750 rpm maximum unless otherwise scheduled on drawings and sized for non-overloading service.
- D Pump impeller shall be trimmed to a minimum of 120% of design flow at the required pump head after balancing or the maximum non-overloading horsepower of the pump, whichever is lower.
- E Base Mounted Pumps: Aligned by qualified technician.
- F Pumps operated by Variable Frequency Drives shall have pump impeller balanced for variable speed operation and shall be provided with shaft grounding rings.
- G 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): Provide in accordance with Section 230934.
 - 3. Provide motor starters for pumps not specified to receive VFDs; see Section 262913.

2.3 IN-LINE PUMPS

- A Closed-Coupled, Single-Stage Pump: Vertical pump with radially- or horizontally-split casing; rated for discharge pressures up to 175 psi (1200 kPa).
- B Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
- C Casing: Cast iron with casing wear ring, seal flush connection, threaded suction, and discharge ports with gauge port and drain plug.
- D Impeller: Bronze or stainless steel, fully enclosed, keyed directly to motor shaft or extension.
- E Shaft: Carbon steel with stainless steel impeller cap screw or nut and stainless steel sleeve.
- F Seal: Carbon rotating against a stationary ceramic seat, 225 degrees F (107 degrees C) maximum continuous duty temperature.
- G Electrical:
 - 1. Motor: RPM as scheduled, open drip-proof (ODP); see Section 230513.
 - 2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

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2.4 END-SUCTION PUMPS

- A Close-Coupled Pump: Base-mounted, long-coupled, single-stage pump with horizontal shaft and radially- or horizontally-split casing rated for discharge pressures up to 175 psi (1200 kPa).
- B Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C Casing: Cast iron with renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction, and discharge flanged connections with gauge ports.
- D Impeller: Stainless steel, balanced, fully enclosed, keyed to shaft.
- E Bearings: Grease lubricated roller or ball bearings.
- F Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.
- G Seal: Carbon rotating against a stationary ceramic seat, 225 degrees F (107 degrees C) maximum continuous duty temperature.
- H Drive: Flexible coupling with coupling guard.
- I Baseplate: Cast iron or fabricated steel with integral drain rim.
- J Electrical:
 - 1. Motor: RPM as scheduled, open drip-proof (ODP); see Section 230513.
 - 2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

PART 3 EXECUTION

3.1 PREPARATION

- A Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
- B Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

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- A Install in accordance with manufacturer's instructions.
- B Comply with HI 1.4.
- C Provide access space around pumps for service including removing motors, impellers, couplings, and accessories. Provide no less than minimum space recommended by manufacturer.
- D 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 (102 mm) and over.
- E Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.
 - 1. See Section 230548.
- F Provide line sized shut-off valve and strainer or suction diffuser on pump suction, and line sized check valve, balance valve, and shut-off valve on pump discharge.
- G Provide air cock and drain connection on horizontal pump casings.
- H Provide drains for bases and seals, piped to and discharging into floor drains.
- I Check, align, and certify alignment of base-mounted pumps prior to start-up.
- J Install close-coupled and base-mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. See Section 033000.
 - 1. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
 - 2. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
 - 3. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- K Lubricate pumps before start-up.
- L Controls: Interface each pump starter or VFD with HVAC controller; see Section 230923.

3.3 STARTUP SERVICE

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- A Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.4 DEMONSTRATION

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

END OF SECTION 232123

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SECTION 232500
HVAC WATER TREATMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Materials.
 - 1. System cleaner.
 - 2. Closed system treatment (water).
- B By-pass (pot) feeder.
- C Solution tanks.
- D Test equipment.
- E Side-stream filtration equipment.

1.2 RELATED REQUIREMENTS

- A Section 232113 - Hydronic Piping.
- B Section 232114 - Hydronic Specialties.

1.3 SCOPE

- A The water treatment supplier shall provide the following services:
 - 1. All pre-operational system cleanout chemicals.
 - 2. Chemical feed equipment as described herein.
 - 3. All necessary test equipment for control of chemicals.
 - 4. Instruct the Contractor on pre-cleaning procedures.
 - 5. Instruct the Contractor on the installation of the feed equipment.
 - 6. Provide training for the operating personnel.
 - 7. Provide one year field service and consultation which will include monthly service visits with written test results, recommended adjustments, and a written report to the Owner.
 - 8. Provide one year supply of chemical treatment.
 - 9. Provide laboratory testing of samples as needed.
 - 10. System start-up assistance.

1.4 PERFORMANCE REQUIREMENTS

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- A Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
- B Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C Closed hydronic systems, including hot-water heating, shall have the following water qualities:
 - 1. pH: Maintain a value within 9.0 to 10.5.
 - 2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
 - 3. Soluble Copper: Maintain a maximum value of 0.20 ppm.
 - 4. TDS: Maintain a maximum value of 2,500 ppm.
 - 5. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.

1.5 SUBMITTALS

- A Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- B Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
- C Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.
- D Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Sufficient chemicals for treatment and testing during required maintenance period.

1.6 QUALITY ASSURANCE

- A Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.

1.7 EXTRA MATERIALS AND SERVICE

- A Furnish one (1) year supply of chemicals to maintain all systems.
- B Provide one year service.

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PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Aqua-Chem Inc,
- B AmSolv-Amrep, Inc
- C GE Water & Process Technologies
- D Nalco, an Ecolab Company
- E H-O-H Water Treatment Chemicals

2.2 REGULATORY REQUIREMENTS

- A Comply with applicable codes for addition of non-potable chemicals to building mechanical systems and to public sewage systems.
- B Perform work in accordance with local health department regulations.

2.3 MATERIALS

- A Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.
- B System Cleaner:
 - 1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products; sodiumtripoly phosphate and sodium molybdate.
 - 2. Biocide chlorine release agents such as sodium hypochlorite or calcium hypochlorite or microbiocides such as quarternary ammonia compounds, tributyltin oxide, methylene bis (thiocyanate).
- C Closed System Treatment (Water):
 - 1. Sequestering agent to reduce deposits and adjust pH; polyphosphate.
 - 2. Corrosion inhibitors; boron-nitrite, sodium nitrite and borax, sodium totyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
 - 3. Conductivity enhancers; phosphates or phosphonates.

2.4 BY-PASS (POT) FEEDER

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- A 2 quart (1.9 L) quick opening cap for working pressure of 125 psi (860 kPa).
- B Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

2.5 TEST EQUIPMENT

- A Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness.
- B Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 - 1. Two station rack for closed-loop systems.

2.6 SIDE-STREAM FILTRATION SYSTEM

- A System: Flow indicator, filter housing with cartridge filter, shut-off valves, and flow control valve.
- B Vessels manufactured from polished 304 Stainless steel and rated for 150 psi at 300 degrees F.
- C Filtration bag shall be polypropylene and meet FDA standards. Have high dirt holding capacity. The ability to remove both solid and gelatinous particles.
- D Provide filtration bag for construction and 2 additional to be turned over to the Owner.

PART 3 EXECUTION

3.1 PREPARATION

- A Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
- B Place terminal control valves in open position during cleaning.
- C Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

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- A Install in accordance with manufacturer's instructions.
- B Install piping adjacent to equipment to allow service and maintenance.
- C Install shutoff valves on HVAC water-treatment equipment inlet and outlet. General-duty valves are specified in Division 23 Section "General-Duty Valves for HVAC Piping."
- D Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings.

3.3 CLOSED SYSTEM TREATMENT

- A Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.
- B Introduce closed system treatment through bypass feeder when required or indicated by test.
- C Provide 3/4 inch (19 mm) water coupon rack around circulating pumps with space for 4 test specimens.

3.4 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B 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. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 4. 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.
 - 5. 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.

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6. 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.
7. Repair leaks and defects with new materials and retest piping until no leaks exist.

3.5 CLOSEOUT ACTIVITIES

- A Training: Train Owner's personnel on operation and maintenance of chemical treatment system.
 1. Provide minimum of two hours of instruction for two people.
 2. Have operation and maintenance data prepared and available for review during training.
 3. Conduct training using actual equipment after treated system has been put into full operation.

3.6 MAINTENANCE

- A Perform maintenance work using competent and qualified personnel under the supervision of the equipment manufacturer or original installer.
- B Provide service and maintenance of treatment systems for one year from Date of Substantial Completion.
- C Provide monthly technical service visits to perform field inspections and make water analysis on-site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit.
- D Provide laboratory and technical assistance services during this maintenance period.
- E Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program, and make recommendations in writing based upon these inspections.
- F A minimum of a two hour training program will be provided for the maintenance personnel within 30 days of startup of the systems and as needed thereafter even if dictated by turnover of personnel. Response to emergency calls shall be within 24 hours. Records of service calls shall be available for review.

END OF SECTION 232500

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SECTION 233100
HVAC DUCTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Metal ducts.
- B Flexible ducts.
- C Air plenums and casings.
- D Ducts for laboratory and industrial-grade applications.

1.2 RELATED REQUIREMENTS

- A Section 078400 - Firestopping.
- B Section 230713 - Duct Insulation: External insulation and duct liner.
- C Section 233300 - Air Duct Accessories.
- D Section 233600 - Air Terminal Units.
- E Section 233700 - Air Outlets and Inlets.

1.3 REFERENCE STANDARDS

- A ANSI Z9.5 - Laboratory Ventilation; 2022.
- B ASHRAE Std 126 - Method of Testing HVAC Air Ducts; 2020.
- C ASME AG-1 - Code on Nuclear Air and Gas Treatment; 2019.
- D ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip; 2023b.

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- E ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- F 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).
- G ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- H NFPA 45 - Standard on Fire Protection for Laboratories Using Chemicals; 2019.
- I NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- J NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2024.
- K NFPA 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids; 2020.
- L SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- M SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; 2012.
- N SMACNA (ROUND) - Round Industrial Duct Construction Standards; 2013.
- O UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A Product Data: Provide data for duct materials.
- B Shop Drawings: Indicate duct fitting types, gauges, sizes, welds, and configuration.
- C Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
 - 1. Show duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.

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2. Coordination Drawings are submitted for information only; they are not a reviewed submittal.
- D LEED Submittals:
1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment" and ASHRAE 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
 2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 3. Product Data: For adhesives and sealants, indicating VOC content.
- E Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate per appropriate seal class, following SMACNA (LEAK).
- F Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

PART 2 PRODUCTS

2.1 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 is not allowed.
- C Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D Duct Sealing and Leakage in accordance with Static Pressure Class:
1. Duct Pressure Class and Material for Common Mechanical Ventilation Applications:
 - a. Supply Air for Terminal Units and Constant Volume Air-Handling Units: 2 in-wc pressure class, galvanized steel.
 - b. Supply Air for Variable-Air-Volume Air-Handling Units, Upstream of Terminal Units: 4 in-wc pressure class, galvanized steel.
 - c. Outdoor, Return, Relief, and Transfer Air: 2 in-wc pressure class, galvanized steel.
 - d. General Exhaust Air: 2 in-wc pressure class, galvanized steel.
 2. Low Pressure Service: Up to 2 in-wc (500 Pa):
 - a. Seal: Class A, apply sealing of transverse joints, longitudinal seams, and duct wall penetrations.
 - b. Leakage:
 - 1) Rectangular: Class 12 or 12 cfm/100 sq ft (340 Lpm/9.3 sq m).
 - 2) Round: Class 6 or 6 cfm/100 sq ft (170 Lpm/9.3 sq m).

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3. Medium Pressure Service: Above 2 in-wc (500 Pa):
 - a. Seal: Class A, apply sealing of transverse joints, longitudinal seams, and duct wall penetrations.
 - b. Leakage:
 - 1) Rectangular: Class 8 or 8 cfm/100 sq ft (230 Lpm/9.3 sq m).
 - 2) Round: Class 4 or 4 cfm/100 sq ft (115 Lpm/9.3 sq m).
- E 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. 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.
- F Elbow Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - b. Radius-to Diameter Ratio: 1.5.
 - c. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - d. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.
- G Branch Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.

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- b. Rectangular Main to Round Branch: Conical spin in.
- 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher; 45-degree lateral.

2.2 METAL DUCTS

A Material Requirements:

- 1. Galvanized Steel: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
 - a. Finishes for Surfaces Exposed to View: Mill phosphatized.
- 2. Stainless Steel: ASTM A480/A480M, Type 304 or 316.

B Rectangular Metal Duct:

- 1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- 2. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 3. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 4. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C Round Metal Ducts:

- 1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- 2. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

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3. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 4. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 5. Round Single Wall Duct: Round lock seam duct with galvanized steel outer wall.
 6. Round Connection System: Interlocking duct connection system in accordance with SMACNA (DCS).
- D Connectors, Fittings, Sealants, and Miscellaneous:
1. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - a. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - b. VOC Content: Not more than 250 g/L, excluding water.
 - c. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
 - d. For Use with Flexible Ducts: UL labeled.
 2. Gasket Tape:
 - a. Provide butyl rubber gasket tape for a flexible seal between transfer duct connector (TDC), transverse duct flange (TDF), applied flange connections, and angle ring connections.

2.3 FLEXIBLE DUCTS

- A Flexible Ducts: UL 181, Class 1, polyethylene film, mechanically fastened and rolled using galvanized steel to form spiral helix.
1. Insulation: None.
 2. Pressure Rating: 10 in-wc (2.50 kPa) positive and 5 in-wc (1.25 kPa) negative.
 3. Maximum Velocity: 5500 fpm (27.9 m/sec).
 4. Temperature Range: Minus 20 degrees F to 250 degrees F (Minus 28 degrees C to 121 degrees C).
 5. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Flexmaster USA, a brand of Masterduct, Inc.
 - b. McGill AirFlow LLC.
 - c. Ward Industries, Inc.
- B Insulated Flexible Ducts: UL 181, Class 1, polyethylene film, mechanically fastened and rolled using galvanized steel to form spiral helix.
1. Insulation: Fiberglass insulation with metallic vapor barrier.

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2. Insulation R-Value: R6 minimum, or as required by ASHRAE 90.1.
3. Inner Core: Polyethylene vapor barrier core.
4. Pressure Rating: 10 in-wc (2.50 kPa) positive and 5 in-wc (1.25 kPa) negative.
5. Maximum Velocity: 4000 fpm (20.3 m/sec).
6. Temperature Range: Minus 20 degrees F to 250 degrees F (Minus 28 degrees C to 121 degrees C).
7. Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - a. Flexmaster USA, a brand of Masterduct, Inc.
 - b. McGill AirFlow LLC.
 - c. Ward Industries, Inc.

2.4 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 (1.52 mm) sheet steel back facing and 22-gauge, 0.029-inch (0.76 mm) perforated sheet steel front facing with 3/32 inch (2.4 mm) diameter holes on 5/32 inch (4 mm) centers.
 3. Construct panels 4 inches thick, packed with 4.5 pcf (72 kg/cu m) minimum glass fiber insulation media, on inverted channel of 16-gauge, 0.059-inch (1.52 mm) sheet steel.
 4. Mount floor-mounted plenum or casings on 4-inch (100 mm) high concrete curbs. At floor, rivet panels on 8-inch (200 mm) centers to angles. Where floors are acoustically insulated, provide liner of galvanized 18-gauge, 0.052-inch (1.31 mm) expanded metal mesh supported at 12-inch (300 mm) centers, turned up 12 inches (300 mm) 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 (150 by 150 mm) size.
- D Thermal Panels:
1. Material: Steel-faced composite panel with noncombustible structural high density mineral fiber core for plenum fabrication.
 - a. Facing: Galvanized steel (G90), 24 gauge, 0.0275 inch (0.701 mm).
 - b. Finish: Unpainted.
 - c. Core: Mineral wool board.
 - d. Structural: Nonload bearing.
 2. Panel Thickness: 4 inches (100 mm).
 3. R-Value: 18 when tested in accordance with ASTM C177.

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2.5 DUCTS FOR LABORATORY AND INDUSTRIAL-GRADE APPLICATIONS

A Sectional Shape and Material Requirements:

1. Round Metal Duct:
 - a. Pressure Class: Plus or minus 4 in-wc (995 Pa).
 - b. Maximum Air Service Temperature:
 - c. Minimum Duct Thickness: Duct Class 1, 2 and 5; 18 gauge, 0.048 inch (1.2 mm).
 - d. Compliance: Provide ductwork, fittings, supports, hangers, and appurtenances:
 - 1) Round: SMACNA (ROUND) construction standard.

B Laboratory Exhaust Applications:

1. Fume Hood Cabinet Exhaust:
 - a. Minimum 20-gauge, 0.035-inch (0.95 mm) Type 316 stainless steel, unless noted otherwise.
 - 1) Fabricate in accordance with ductwork manufacturer's instructions; test duct system to sustain positive and negative pressures in accordance with ASHRAE Std 126 and ASME AG-1.
 - b. Provide ductwork and appurtenances in accordance with NFPA 91 requirements except where NFPA 45 applications take precedence.
 - c. Coordinate duct, fittings, hangers, and accessories to comply with ANSI Z9.5.
 - d. Design, fabricate, and install liquidtight preventing exhaust leakage into the building.

2.6 HANGERS AND SUPPORTS

A Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

D Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.

E Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

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2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 EXECUTION

3.1 INSTALLATION

- A Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B Install, support, and seal ducts in accordance with SMACNA (DCS).
- C Install products following the manufacturer's instructions.
- D Comply with safety standards NFPA 90A and NFPA 90B.
- E During construction, provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering the ductwork system.
- F Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- G Install ducts with fewest possible joints.
- H Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- I Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- J Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- K Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

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- L Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- M Flexible Ducts: Connect to metal ducts with draw bands plus tape.
- N Install insulated flexible ducts on all systems requiring duct insulation per 230713.
- O Duct sizes indicated are precise inside dimensions. For lined ducts, maintain sizes inside lining.
- P Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- Q Use double nuts and lock washers on threaded rod supports.
- R Connect terminal units to supply ducts with one foot (300 mm) maximum length of flexible duct. Do not use flexible duct to change direction.
- S Connect diffusers or light troffer boots to low-pressure ducts directly or with 5 feet (1.5 m) maximum length of flexible duct held in place with strap or clamp.
- T Set plenum doors at 6 to 12 inches (150 to 300 mm) above floor. Arrange door swings so that fan static pressure holds door in closed position.
- U At exterior wall louvers, seal duct to louver frame and install blank-out panels insulated to match R-value of adjacent wall.
- V Plenums and Casings:
 - 1. Mount floor-mounted casings on 4 inch (100 mm) high concrete curbs.
 - 2. At floor, rivet panels on 8 inch (200 mm) centers to angles.
 - 3. Where floors are acoustically insulated, provide liner of galvanized 18-gauge, 0.052-inch (1.31 mm) expanded metal mesh supported at 12-inch (300 mm) centers, turned up 12 inches (300 mm) at sides with sheet metal shields.
- W Fire Partitions: Provide firestopping sealing. See Section 078400.
- X Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 for fire and smoke dampers and specific installation requirements of the damper UL listing.

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Y Duct Accessories, Terminal Units, Inlets, and Outlets: Interconnect as indicated in Sections 233300, 233600, and 233700.

Z Duct Insulation: Provide duct insulation. See Section 230713.

AA Installation of Exposed Ductwork

1. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
2. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
3. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
4. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
5. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.2 HANGERS AND SUPPORTS

A Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than or equal to 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 - OEC EDIT IN PROGRESS - Vibration and Seismic Controls for HVAC.

C Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D Hangers Exposed to View: Threaded rod and angle or channel supports.

E Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

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- F Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 FIELD QUALITY CONTROL

- A Perform tests and inspections.
- B Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Ducts with a Pressure Class Higher than 3 in-wc: Test representative duct sections totaling no less than 25 percent of total installed duct area.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 - 5. Test for leaks before applying external insulation.
 - 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
- C Duct system will be considered defective if it does not pass tests and inspections.
- D Prepare test and inspection reports.

3.4 CLEANING

- A Clean duct systems after installation and before testing, adjusting, and balancing as required so that entire air distribution system is free of dirt and debris.
- B Use service openings for entry and inspection.
 - 1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Provide drainage and cleanup for wash-down procedures.

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END OF SECTION 233100

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SECTION 233300
AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Air turning devices/extractors.
- B Backdraft dampers.
- C Combination fire and smoke dampers.
- D Duct access doors.
- E Duct test holes.
- F Fire dampers.
- G Flexible duct connectors.
- H Smoke and fire-smoke damper test module.
- I Bubble-tight dampers.

1.2 RELATED REQUIREMENTS

- A Section 233100 - HVAC Ducts.

1.3 REFERENCE STANDARDS

- A NFPA 80 - Standard for Fire Doors and Other Opening Protectives; 2025.
- B NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- C NFPA 92 - Standard for Smoke Control Systems; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

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- D NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2024.
- E NFPA 105 - Standard for Smoke Door Assemblies and Other Opening Protectives; 2025.
- F SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- G UL 33 - Safety Heat Responsive Links for Fire-Protection Service; Current Edition, Including All Revisions.
- H UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.
- I UL 555C - Standard for Safety Ceiling Dampers; Current Edition, Including All Revisions.
- J UL 555S - Standard for Smoke Dampers; Current Edition, Including All Revisions.
- K UL 1978 - Grease Ducts; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A 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.
- B Manufacturer's Installation Instructions: Provide instructions for fire dampers and combination fire and smoke dampers.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Manufacturers for Dampers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
 - 3. Pottorff.
 - 4. Ruskin Company.
 - 5. TAMCO.

2.2 AIR TURNING DEVICES/EXTRACTORS

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- A General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vaness and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- B Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.3 BACKDRAFT DAMPERS

- A Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch (150 mm) width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.4 COMBINATION FIRE AND SMOKE DAMPERS

- A Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- B Provide factory sleeve and collar for each damper.
- C Multiple Blade Dampers: Fabricate with 16 gauge, 0.0598 inch (1.52 mm) 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 (3.2 by 12.7 mm) plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch (12.7 mm) actuator shaft.
- D 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.
- E Electro Thermal Link: Fusible link melting at 165 degrees F (74 degrees C); 120 volts, single phase, 60 Hz; UL listed and labeled.

2.5 DUCT ACCESS DOORS

- A General Requirements: Fabricate access doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."
- B Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick-fastening locking devices. For insulated ducts, install minimum 1-inch (25 mm) thick insulation with sheet metal cover.
 - 1. Less Than 12 inches (300 mm) Square: Secure with sash locks.

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2. Up to 18 inches (450 mm) Square: Provide two hinges and two sash locks.
3. Up to 24 by 48 inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
4. High Temperature Duct Access Doors:
 - a. Comply with NFPA 96.
 - b. Comply with UL 1978.
 - c. Panel and Frame: Minimum thickness 0.0428-inch stainless steel.
 - d. Fasteners: Stainless steel. Panel fasteners shall not penetrate duct wall.
 - e. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
 - f. Minimum Pressure Rating: 10-inch wg, positive or negative.

C Access doors with sheet metal screw fasteners are not acceptable.

2.6 REMOVABLE DUCT SECTIONS

- A Fire and Smoke Damper Access: Ductwork serving dampers 12 inches by 12 inches rectangular and 12 inches diameter round inside clear dimension and smaller to be provided with a removable ductwork section for damper inspection and maintenance. Removable ductwork section to function without the use of tools.
- B Clamp Access: Manufacture rectangular access section suitable for duct pressure class. Clamping type removable ductwork section with draw latch. Access section shall be manufactured to maintain 100 percent of ductwork free area. Allowable leakage: 0.5 CFM for 2 inches wg.
- C Material: Minimum 26-gauge galvanized ASTM A527, 12 inches long.
- D Flange Connection: 18 Gauge galvanized sheet metal construction.
- E Seams: Pittsburgh lock. Seal seams in accordance with SMACNA DCS.
- F Clamps: 20 Gauge galvanized with zinc coated draw latch.
- G Gasket: Neoprene, 3/16 inches by 1-1/4 inches. Gasket profile forms to the inside of clamp and seals the outer edges of the ductwork flanges.

2.7 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.

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2.8 FIRE DAMPERS

- A Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- B Ceiling (Radiation) Dampers: Galvanized steel, 22-gauge, 0.0299-inch (0.76 mm) frame and 16-gauge, 0.0598-inch (1.52 mm) flap, two layers of 0.125-inch (3.2 mm) thick ceramic fiber on top side and one layer on bottom side for round flaps, with locking clip.
 - 1. Boot Fitting: Factory-provided el type (90 degree). Include field-provided collar.
 - 2. Rated for one, two, or three hour service to match rating of ceiling assembly in compliance with UL 555C.
- C Horizontal Dampers: Galvanized steel, 22-gauge, 0.0299-inch (0.76 mm) 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 (250 Pa) pressure-class ducts up to 12 inches (300 mm) in height.
- E Fusible Links: UL 33, separate at 165 degrees F (73.8 degrees C) with adjustable link straps for combination fire/balancing dampers.

2.9 FLEXIBLE DUCT CONNECTORS

- A Fabricate in accordance with SMACNA (DCS) and as indicated.
- B Flexible Duct Connections: Fabric crimped into metal edging strip.
 - 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz/sq yd (1.0 kg/sq m).
 - a. Net Fabric Width: Approximately 3 inches (75 mm) wide.
 - b. For outdoor installations, double coated with weathreproof, synthetic rubber resistant to UV rays and ozone.

2.10 SMOKE AND FIRE-SMOKE DAMPER TEST MODULE

- A Addressable fire alarm system proprietary controller module preconfigured for remote testing of dedicated smoke damper or combination fire-smoke damper.
- B Provide module, accessories, and connectivity to meet NFPA 80 and NFPA 105 requirements.

2.11 BUBBLE-TIGHT DAMPERS

- A Constructed of 304 stainless steel.

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- B The damper blade shall consist of an 11 ga cylindrical body, 3/16" thick connection flanges with neoprene gaskets, and two 3/16" thick blades reinforcing a replaceable silicone gasket. the blade assembly shall rotate 90 degrees to create bubble-tight seal to the inside of the damper body.
- C The damper shall incorporate an all welded design with all pressure retaining joints continuously welded. At a minimum all welds shall be wire brushed and or buffed to remove heat discoloration and any sharp edges.
- D The damper blade shall be tested at 10" water gage per AG-1, 2012 mandatory appendix TA-III, Article TA-III-4200.
- E Damper shall be equipped with a motorized actuator with a button operator to be installed on wall.

PART 3 EXECUTION

3.1 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 backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, smoke dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96 Provide minimum 8 by 8 inch (200 by 200 mm) size access door for hand and shoulder access, or as indicated on drawings. Provide minimum 4 by 4 inch (100 by 100 mm) size access door for balancing dampers only. Review locations prior to fabrication.
- D Install removable duct sections in ductwork 12 inches by 12 inches rectangular and 12 inches diameter round and smaller for inspection and maintenance of fire dampers, smoke dampers, and combination fire and smoke dampers.
- E Provide duct test holes where indicated and required for testing and balancing purposes.
- F Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire-rated components, and where required by authorities having jurisdiction. Install in accordance with UL listing and with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

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- G Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
- H Operate smoke dampers to verify full range of movement and verify that proper heat-response device is installed. Demonstrate re-setting of fire dampers to Owner's representative.
- I At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- J For fans developing static pressures of 5.0 inches (1250 Pa) and over, cover flexible connections with leaded vinyl sheet, held in place with metal straps.
- K 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.
- L 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

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SECTION 233400
HVAC FANS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Centrifugal roof ventilators.
- B Inline centrifugal fans.
- C Laboratory-fume exhaust fans.

1.2 RELATED REQUIREMENTS

- A Section 230513 - Common Motor Requirements for HVAC Equipment.
- B Section 230548 - Vibration Controls for HVAC.
- C Section 233300 - Air Duct Accessories: Dampers.

1.3 REFERENCE STANDARDS

- A AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2016, with Errata (2018).
- B AMCA 211 - Certified Ratings Program Product Rating Manual for Fan Air Performance; 2022, with Editorial Revision (2023).
- C AMCA 260 - Laboratory Methods of Testing Induced Flow Fans for Rating; 2020.
- D AMCA 300 - Reverberation Room Methods of Sound Testing of Fans; 2024.
- E AMCA 311 - Certified Ratings Program Product Rating Manual for Fan Sound Performance; 2016.
- F NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.

1.4 SUBMITTALS

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- A 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.
- B Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

PART 2 PRODUCTS

2.1 CENTRIFUGAL ROOF EXHAUSTERS

- A Manufacturers:
 - 1. Greenheck Fan Corporation
 - 2. Loren Cook Company
 - 3. Twin City Fan & Blower
- B Fan Unit: Direct driven as indicated in Drawing schedule, with spun aluminum housing; resilient mounted motor; 1/2 inch (13 mm) mesh, 0.62 inch (1.6 mm) thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- C Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D Roof Curb: 24 inch (600 mm) high self-flashing of galvanized steel with continuously welded seams, insulation and curb bottom. Size and features as required to suit roof opening and fan base.
- E Disconnect Switch: Factory wired, nonfusible, in housing for thermal overload protected motor.
- F Motorized Damper: Aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, line-voltage actuator with power open and spring return.
- G 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 bearings.
- H Accessories:
 - 1. Variable-Speed Motor Controller: Variable-frequency drive or electronically commutated motor to reduce speed from 100 to less than 50 percent.
 - 2. Hinged sub-base to provide access to damper or as cleanout for grease applications.

2.2 INLINE CENTRIFUGAL FANS

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- A Manufacturers:
 - 1. Greenheck Fan Corporation
 - 2. Loren Cook Company
 - 3. Twin City Fan & Blower
- B Housing: Galvanized steel, square with side panels are to be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- D Disconnect Switch: Factory wired, nonfusible, in housing for thermal overload protected motor.
- E Fan Wheels: Aluminum airfoil blades welded to aluminum hub.
- F Disconnect Switch: Cord and plug-in housing for thermal overload protected motor and wall mounted switch.

2.3 LABORATORY FUME-EXHAUST FANS

- A Manufacturers:
 - 1. Greenheck Fan Corporation
 - 2. Loren Cook Company
 - 3. Strobic Air Corporation
 - 4. Twin City Fan & Blower
 - 5. Skyplume Technologies
- B General Requirements:
 - 1. Provide fan-assembly manufactured to sustain structural integrity without external guy-wires or supplemental supports at wind speeds up to 125 mph (201 kmh).
 - 2. Fan performance tested in accordance with AMCA 210, AMCA 260, and AMCA 300.
 - 3. Fan performance ratings certified in accordance with AMCA 211 and AMCA 311.
- C Application:
 - 1. Multiple Exhaust Loads including Fume Hoods and Lab Equipment:
 - a. Fan Type: Direct-driven, inverter-duty motor fan with VFD finished with electrostatic powder protective coating; see Section 262923. Include fan-fitted air-mixing plenum box with side-mounted bypass damper sized to handle 25 percent over minimum flow.
 - b. Exhaust Capacity: Select dual fan set for weekly lead-lag operation to handle combined peak hood-exhaust airflow rates, system static pressure loss with 20 percent load-capacity factor, and minimum discharge plume height of 30 feet (9.1 m) above roof level.

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D Fan Section Requirements:

1. Impeller:
 - a. Non-overloading, backward-inclined centrifugal.
 - b. Material: Aluminum.
2. Fan Shaft:
 - a. Ground and polished steel with anticorrosive coating.
 - b. First critical speed at least 25 percent over maximum cataloged operating speed.
 - c. Enclosed over OSHA recommended safety-yellow painted guards.
3. Bearings:
 - a. 100 percent factory tested surface-mounted bearings outside of the airstream.
 - b. Operate during a minimum L10 service life in excess of 100,000 hours at maximum cataloged operating speed.
4. Belt-drive Assembly:
 - a. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
 - b. Belts: Static-free and oil resistant.
 - c. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
 - d. Motor pulley adjustable for final system balancing, readily accessible for maintenance.
5. Housing:
 - a. Construct of heavy gauge aluminum with standard factory finish.
 - b. Mounting Base:
 - c. Construct drive frame assembly of heavy gauge steel, mounted on vibration isolators.
 - d. Provide breather tube for fresh air motor cooling and wiring.
 - e. Minimum Assembly Height: 120 inches (3048 mm) above the roof surface.
6. Isolation Damper:
 - a. With parallel blade damper, constructed of matching materials and finish.
 - b. Provided by manufacturer, bolted to access drawer or panel for easy removal from contaminated airstream.
 - c. With two-position damper actuator:
 - 1) Provided by manufacturer.
 - 2) Operate interlocked with fan starter.
 - 3) With integral auxiliary switches to monitor blade position status.
 - 4) Rated for NEMA EN 10250, Type 4 (IP66) environment within protective weather-housing out of contaminated airstream, connected through linkages.
7. Fan Discharge Outlet-Nozzle:
 - a. Constant Stack-velocity Discharge: Variable-volume shaped nozzle manufactured to facilitate attaining a required air-discharge velocity of reduced exhaust airflow.
8. Fan Inlet Flow Sensor: Provide factory-mounted pitot tube-based differential pressure sensor probe ready for connection into differential pressure-based flow transmitter.
 - a. Transmitter Housing: Provide NEMA EN 10250, Type 4 enclosure.

E Disconnect Switch:

1. Factory-mounted in NEMA EN 10250, Type 3R box wired in compliance with Section 260583.

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2. Switchbox Finish: Manufacturer's standard unless otherwise indicated.

F Air-Mixing Plenum Box:

1. Continuously welded insulated box using assembly matching material and finish on both interior and exterior sides.
2. Provide factory-mounted box on heavy-duty roof curb with integral box-lifting lugs and skirt.
3. Insulation: Water-resistant sound-absorbing material.
4. Include bolted and gasketed access panels for servicing and maintenance.
5. Locate exhaust intake opening on the bottom end fitted with matching duct connecting fitting and safety screen.
6. Locate fan inlet opening on the upper end fitted with matching assembly-base and flow straightener.
7. Air-bypass Intake:
 - a. With opposed blade damper, constructed of matching materials and finish.
 - b. With proportional damper actuator:
 - 1) Provided by manufacturer.
 - 2) Integral potentiometer to monitor blade position.
 - 3) Rated for NEMA EN 10250, Type 4 (IP66) environment within protective weather-housing out of contaminated airstream, connected through linkages.
 - c. Covered by damper enclosing weatherhood with intake birdscreen.

G Roof Curbs:

1. 24 inch (600 mm) high flanged, self-flashing of matching material and finish with continuously welded seams.
2. Provide integral formed steel support framework with curb cap guides.

PART 3 EXECUTION

3.1 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 Fans supported from building structure:
1. Install fans with threaded steel rods, elastomeric hangers, and flexible electrical leads, see Section 230548.
 2. Install flexible connections between fan and ductwork; see Section 233300. Ensure metal bands of connectors are parallel with minimum 1 inch (25 mm) flex between ductwork and fan while running.

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3. Ceiling Exhaust Fans: Suspend units from structure; use steel wire or metal straps.

3.2 STARTUP SERVICE

A Perform startup service:

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
7. Adjust belt tension.
8. Adjust damper linkages for proper damper operation.
9. Verify lubrication for bearings and other moving parts.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
12. Shut unit down and reconnect automatic temperature-control operators.
13. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 233400

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SECTION 233433
AIR CURTAINS

PART 1 GENERAL

1.1 SECTION INCLUDE

- A Air curtains.

1.2 REFERENCE STANDARDS

- A AMCA 220 - Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating; 2021.

1.3 SUBMITTALS

- A Product Data: Manufacturer's descriptive literature for products specified in this section; indicate options specified.
 - 1. Rated Capacities: Airflow (cfm), discharge velocity (fpm), noise rating (dBA), motor quantity and horsepower, electrical ratings (full load amps, volts/phase/hertz), outlet velocity uniformity (percentage), unit assembly weight (lb).
- B Manufacturer's Instructions: Printed installation instructions for each product specified.
- C Operation and Maintenance Data: Manufacturer's printed instructions for operating and maintaining air curtain components.

1.4 WARRANTY

- A Provide manufacturer's standard warranty for replacement of parts, components, and accessories provided with air curtain whether or not they are direct product manufactured by air curtain manufacturer or third party.
 - 1. Unheated Units: 60 months from time of shipment from manufacturer.
 - 2. Heated Units: 24 months from time of shipment from manufacturer.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Berner International Corp

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B Mars Air Systems LLC

C Powered Aire Inc

2.2 AIR CURTAINS

A Description: Self-contained, electrically operated air curtain. Suitable for mounting at head or jamb of door or service window opening.

1. Rated Maximum Mounting Height: As indicated on drawings.
2. Rated Opening Width: As indicated on drawings.

B Housing:

1. Material: Galvanized steel.
2. Factory-provided mounting brackets.
3. Finish: Painted epoxy.
4. Color: Manufacturer's standard.

C Air Intake: Aluminum mesh air-intake filter; removable and cleanable.

D Blower Assembly: Heavy-duty motor; forward curved centrifugal fans, double inlet, double width.

E Performance: Tested in accordance with AMCA 220

1. Average Outlet Velocity: As indicated on drawings.
2. Air Flow: Indicated on drawings.

F Controls:

1. Magnetic Door Switch with Time Delay Relay: 24-volt door switch remotely installed in door area to activate unit each time door opens and deactivate unit each time door closes. Time delay relay operates air curtain for specified time (adjustable from 1 to 100 seconds) after door closes. Model SM300 door switch (commercial) or Model SM226 door switch (industrial).
2. BACnet Controller: Factory-installed/wired controller to integrate with building management system to control/monitor air curtain; pre-programmed for common air curtain applications. Heated units include unit or wall mount temperature sensor; unit mounted.
3. Disconnect: Remote mounted; fused.

G Hot Water Heat: Capacity as indicated on drawings, with temperature limit controller.

1. Heater Assembly: Seamless copper tubes expanded into aluminum fins.

H Thermostat: Wall-mounted, 24 V.

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PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that required utilities are in correct location and are of correct capacities for specified products.
- B Verify that mounting surfaces have sufficient strength to support units.
- C Verify that space is ready for installation of units.
- D Verify clearances required to maintain the units and to protect combustible materials.

3.2 INSTALLATION

- A Install air curtains in accordance with shop drawings and manufacturer's printed installation instructions.
- B Maintain clearances required to maintain the units and to protect combustible materials.
- C Ensure proper connection to utilities.
- D Clean inside and outside of each air curtain to remove dirt, debris, grease, grime, or other material as necessary to ensure proper operation. Remove loose debris that may be of harm to air curtain operation.
- E Remove, clean, and reinstall cleanable air filters, if provided.
- F Demonstration: Instruct Owner's maintenance personnel on how to adjust, operate, and maintain air curtains

END OF SECTION 233433

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SECTION 233600
AIR TERMINAL UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Single-duct terminal units.
- B Venturi-type air valves.
- C Booster coils.

1.2 RELATED REQUIREMENTS

- A Section 230923 - Direct-Digital Control System for HVAC.
- B Section 230529 - Hangers and Supports for HVAC Piping and Equipment.
- C Section 233100 - HVAC Ducts.

1.3 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 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 ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2019.
- E ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- F ASTM E488/E488M - Standard Test Methods for Strength of Anchors in Concrete Elements; 2022.

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- 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.
- I SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems; 2008.
- J UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A 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.
- B 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.

PART 2 PRODUCTS

2.1 SINGLE-DUCT, VARIABLE-VOLUME UNITS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following or an approved equal.
 - 1. Enviro-Tec.
 - 2. Johnson Controls, Inc.
 - 3. Metalaire, a brand of Metal Industries Inc.
 - 4. Nailor.
 - 5. Price Industries.
 - 6. Titus.
 - 7. Trane Technologies, PLC.
- B 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.
- C Unit Casing:

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1. Minimum 22 gauge, 0.0299 inch (0.76 mm) 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. 3/4 inch (19 mm) 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.
 - b. 3/4 inch (19 mm) 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.
 - c. Liner not to contain pentabrominated diphenyl ether (CAS #32534-81-9) or octabrominated diphenyl ether.
- D Damper Assembly:
1. Heavy-gauge, galvanized steel, or extruded aluminum construction with solid steel, nickel-plated shaft pivoting on HDPE, self-lubricating bearings.
 2. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.
 3. Incorporate low leak damper blades for tight airflow shutoff.
- E Hot Water Heating Coil:
1. Coil Casing: Minimum 22 gauge, 0.0299 inch (0.76 mm) galvanized steel, factory-installed on terminal discharge with rectangular outlet, duct connection type.
 - a. Right or left coil inlets. Contractor to coordinate with installation conditions.
 2. Coil Fins: Aluminum fins, mechanically-bonded to seamless copper tubes.
 3. Coil leak tested to minimum 350 psig (2413 kPa).
 4. Base performance data on tests run in accordance with AHRI 410 and units to bear AHRI 410 label.
- F Electrical Requirements:
1. Terminal units shall be 24V powered unless scheduled with electric reheat.
 2. Equipment wiring to comply with requirements of NFPA 70.
- G Controls:
1. DDC (Direct-Digital Controls):
 - a. Include a factory-installed, unit-mounted, direct-digital controller.
 - b. Bi-directional Damper Actuator: 24 volt, powered closed, spring return open.
 - c. Microprocessor-Based Controller: Air volume controller, pressure-independent with electronic airflow transducers, factory-calibrated maximum and minimum CFMs.
 - 1) Occupied and unoccupied operating mode.
 - 2) Remote reset of temperature or CFM set points.
 - 3) Proportional, plus integral control of room temperature.
 - 4) Monitoring and adjusting with portable terminal.

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- d. Room Sensor:
 - 1) Compatible with temperature controls specified.
 - 2) Wall-mounted, system powered, with temperature set-point adjustment including connection access for portable operator terminal.
- 2. Airflow Sensor: Differential pressure airflow device measuring total, static, and wake pressures.
 - a. Signal accuracy: Plus/minus five percent throughout terminal operating range.

2.2 VENTURI-TYPE AIR VALVES

- A Manufacturers:
 - 1. Antec Controls, a brand of Price Industries, Inc
 - 2. Phoenix Controls, a company of Honeywell International, Inc
 - 3. Critical Room Control (CRC)
- B Type: Pressure independent, field adjustable, maintenance-free, directional-flow tagged, factory calibrated to operate across body-stamped flow curve.
- C Construction:
 - 1. Body Material: Aluminum, 14 gauge, 0.064 inch (1.63 mm), uncoated.
 - 2. Cone Material: Aluminum, 14 gauge, 0.064 inch (1.63 mm), uncoated.
 - 3. Shaft, Bearings, and Links Material: 316 stainless steel.
 - 4. Valve-Assembly Orientation: Horizontal flow.
 - 5. Flow-Valve Type:
 - 6. Actuator Configuration: Electronic, high speed, fail closed.
 - 7. Flow Feedback: Built-in calibrated potentiometer with pressure switch.
- D Operating Range:
 - 1. Flow: As indicated on drawings.
 - 2. Accuracy: Plus or minus 5 percent of scheduled flow setpoints.
- E Auxiliary Heating or Reheating: Provide hot water booster coil.
- F Terminal Unit Controls:
 - 1. Controller: Built-into valve, extend power and communication bus to other system valves.
 - 2. Control Sequence: Dynamic space volume matching to attain area offset setpoint.

2.3 BOOSTER COILS

- A Hot Water Heating Coil:
 - 1. Coil: Two row, seamless copper tubes mechanically expanded into aluminum or aluminum-plated fins arranged in a counter-flow manner with self-venting drainable circuits.

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2. Casing: Slip-in type made of zinc-coated (galvanized) steel.
3. Maximum Working Pressure: 160 psig (1,103 kPa).
4. Performance: AHRI 410 certified and listed with logo shown on product sheet.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that conditions are suitable for installation.
- B Verify that field measurements are as indicated on drawings.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install the inlets of air terminal units and air flow sensors a minimum of three 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 metal strap hangers or threaded rods.
- E Embed anchors in concrete in accordance with ASTM E488/E488M.
- F Do not support from ductwork.
- G Connect to ductwork in accordance with Section 233100.
- H Provide minimum of 5 ft (1.5 m) of 1 inch (25 mm) thick lined ductwork downstream of units.

3.3 IDENTIFICATION

- A Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.4 FIELD QUALITY CONTROL

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- A Provide manufacturer's field representative to test, inspect, instruct, and observe field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.
 - 1. Leak Test:
 - a. After installation, fill water coils and test for leaks.
 - b. Repair leaks and retest until no leaks exist.
 - 2. Operational Test:
 - a. Test and adjust controls and safeties.
 - b. Replace damaged and malfunctioning controls and other equipment.
 - c. Remove and replace malfunctioning units and retest as specified above.

3.5 CLEANING

- A Install new filters.

END OF SECTION 233600

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SECTION 233700
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Diffusers:
 - 1. Critical environment diffusers.
 - 2. Rectangular ceiling diffusers.
 - 3. Linear diffusers.
- B Registers/grilles:
 - 1. Ceiling-mounted, egg crate exhaust and return register/grilles.
 - 2. Wall-mounted, supply register/grilles.
 - 3. Wall-mounted, exhaust and return register/grilles.

1.2 RELATED REQUIREMENT

- A Section 099123 - NOT OEC EDITED - Interior Painting: Painting of ducts visible behind outlets and inlets.

1.3 REFERENCE STANDARDS

- A ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- B NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- C NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2024.
- D SMACNA (ASMM) - Architectural Sheet Metal Manual; 2012.
- E UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.
- F UL 2518 - Standard for Safety Air Dispersion Systems; Current Edition, Including All Revisions.

1.4 SUBMITTALS

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- A 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.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Subject to compliance with requirements, provide products by one of the following or an approved equal.
1. Krueger-HVAC.
 2. Price Industries.
 3. Titus, a brand of Air Distribution Technologies.
 4. Tuttle and Bailey.
- B Source Limitations: For each air outlet type, obtain from single source from single manufacturer.

2.2 RECTANGULAR CEILING DIFFUSERS

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

2.3 LINEAR DIFFUSERS

- A Type: Frame with multiple fixed or adjustable vanes or blades to deflect supply air direction for left, right, or vertical discharge.
- B Fabrication: Aluminum extrusions with factory clear lacquer finish.
- C Color: To be selected by Architect from manufacturer's standard range.
- D Frame: 1-1/4 inch (32 mm) margin with countersunk screw mounting and gasket, mitered end border.

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E Plenum: Integral, galvanized steel, insulated.

2.4 CEILING EGG CRATE EXHAUST AND RETURN GRILLES

A Type: Egg crate style face consisting of 1/2 by 1/2 by 1/2 inch (13 by 13 by 13 mm) grid core.

B Fabrication: Grid core consists of aluminum with mill aluminum finish.

C Color: To be selected by Architect from manufacturer's standard range.

2.5 WALL SUPPLY REGISTERS/GRILLES

A Type: Streamlined and individually adjustable blades, 3/4 inch (19 mm) minimum depth, 3/4 inch (19 mm) maximum spacing with spring or other device to set blades, vertical face, double deflection.

B Fabrication: Material per Drawing schedule with factory baked enamel finish.

C Color: To be selected by Architect from manufacturer's standard range.

2.6 WALL EXHAUST AND RETURN REGISTERS/GRILLES

A Type: Streamlined blades, 3/4 inch (19 mm) minimum depth, 3/4 inch (19 mm) maximum spacing, with spring or other device to set blades, vertical face.

B Fabrication: Material per Drawing schedule with factory baked enamel finish.

C Color: To be selected by Architect from manufacturer's standard range.

2.7 CRITICAL ENVIRONMENTS DIFFUSERS

A General Requirements:

1. Diffuser material to comply with ASTM E84, UL 723, UL 2518, NFPA 90A, and NFPA 90B.

B Laminar Flow Diffusers:

1. Construction: Stainless steel.
2. Frame: Provide framing per manufacturer's recommendations.
3. Dimensions: As indicated on the drawings.
4. Color: To be selected by Architect from manufacturer's standard range.

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PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install diffusers, registers, and grilles level and plumb.
- C Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.
- D Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical.
- E Install diffusers to ductwork with air tight connection and to allow service and maintenance of dampers, air extractors, and fire dampers.
- F 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.
- G Paint ductwork visible behind air outlets and inlets matte black,

3.2 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 234000
HVAC AIR CLEANING DEVICES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Activated carbon filters.
- B Disposable, extended area panel filters.
- C Disposable panel filters.
- D Extended surface high efficiency media filters.
- E High-efficiency particulate (HEPA) air filters.
- F High-containment housing for high-efficiency particulate air filter.
- G Filter frames and housings.
- H Filter gauges.

1.2 REFERENCE STANDARDS

- A ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2017, with Addendum (2022).
- B MIL-STD-282 - Filter Units, Protective Clothing, Gas-Mask Components, and Related Products: Performance-Test Methods; 2015b.
- C UL 586 - High Efficiency, Particulate, Air Filter Units; Current Edition, Including All Revisions.

1.3 SUBMITTALS

- A See Section 013000 - Administrative Requirements for submittal procedures.
- B Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.

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- C Shop Drawings: Indicate filter assembly and filter frames, dimensions, motor locations, and electrical characteristics and connection requirements.

PART 2 PRODUCTS

2.1 ACTIVATED CARBON FILTERS

- A Media:
1. Activated Carbon Density: 34 lb/cu ft (550 kg/cu m), pelletized or granular to 6 by 10 Tyler mesh screen.
 2. Carbon Tetrachloride Activity: Minimum 60 percent; in thin bed.
 3. Trays: Nominal size 24 by 24 by 5/8 inches (610 by 610 by 16 mm) thick.
 4. Carbon: 1.42 cu ft per 1000 CFM (22 kg per 470 L/sec) nominal air flow capacity.

2.2 DISPOSABLE, EXTENDED AREA PANEL FILTERS

2.3 DISPOSABLE PANEL FILTERS

2.4 EXTENDED SURFACE HIGH EFFICIENCY MEDIA FILTERS

2.5 HIGH EFFICIENCY PARTICULATE (HEPA) AIR FILTERS

- A Media: UL 586, pleated, water-resistant glass fiber with aluminum separators:
- B Performance Rating:
1. Efficiency: 99.97 percent at 0.3 micro-meter and higher when tested in accordance with the DOP-smoke (Dioctyl Phthalate) Penetration Test on MIL-STD-282.
 2. Leakage Scan Tested: Certified as pinhole-free at:
 - a. Air velocity capacity of 500 fps (152.4 m/s).
 - b. Resistance from 0.5 in-wc (124.3 Pa) to 2.0 in-wc (497.9 Pa).

2.6 HIGH-CONTAINMENT HOUSING FOR HIGH-EFFICIENCY PARTICULATE AIR FILTER

- A Floor-mounted, self-contained high-pressure housing, 11 gauge, 0.125 inch (3.18 mm), 304 stainless steel.
- B Housing-fitted inlet and outlet transitions to flanged bubble-tight isolation dampers in compliance with Section 253523 fitted with pneumatic operator with manual override.
- C Housing to include valved inlet and outlet test ports to sample air stream and inject decontaminating products.

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- D Housing to include ribbed banging ring behind filter access door to facilitate the contactless filter bag-in bag-out procedure.
- E Housing-mounted pressure gauge with tubing and fittings per filter section scaled to have highest value at least 2.0 in-wc (0.49 kPa) above maximum rated filter resistance capacity.

2.7 FILTER FRAMES AND HOUSINGS

- A Bag in and bag out filter housing
 1. Filter system shall be designed to withstand a pressure 10" water gauge.
 2. The pre/post filters and medium efficiency filter sections incorporate a slide-in design which does not require a locking mechanism.
 3. The primary filter housing shall be equipped with a fluid seal filter clamping mechanism operated by a locking handle that exerts an equal force on the top and bottom edge of each filter when engaging and disengaging the gel filled channel around the perimeter of the filter onto the knife edge. The locking mechanism shall be removable and shall be constructed of 300-series stainless steel.
 4. The filter housing shall be constructed from T-304 11 ga. and 14 ga. stainless sheet metal. All pressure retaining joints shall be continuously welded. At a minimum all welds shall be wire brushed and or buffed to remove heat discoloration and any sharp edges.
 5. The housing shall be equipped with a bag-out ring around each filter access port. Each ring shall have 3 continuous ribs which secure the change-out bag security strap in place and a hemmed outer edge which prevents tearing the bag.
 6. A minimum of 4 feet clearance in front of the filter system is required for filter change-out.
 7. A replaceable silicone gasket shall be installed around the perimeter of the filter access doors. Each door shall be secured in place using a standard door bolt with aluminum star knobs.
 8. Static pressure taps shall be located on the top of the filter system. Taps shall be 1/4" NPT stainless steel half couplings.
 9. The filter system shall be equipped with bubble-tight flat blade dampers which consist of a round body with silicone gasket sandwiched between two 3/16" thick stainless steel blades. The blade assembly shall rotate 90 degrees to seal against the damper body walls. The damper blade shall be tested at 10" water gauge to ensure bubble tightness per AG-1, 2012 mandatory appendix DA-1 and the entire damper body shall be tested as part of the total assembly.
 10. The damper shall be equipped with a 1/4 turn spring-return electric actuator with travel stops, position indicator, limit switches, NEMA 4X enclosure, low power heater, manual override. The actuator shall operate on 120VAC.
 11. The filter system shall be tested in accordance with ANSI/ASME NQA-1 "Quality Program Requirements for Nuclear Facilities". Housing shall be tested for filter fit, operation of filter clamping mechanism, knife edge alignment, and leak tightness. Both the overall system and the filter sealing surface shall be leak tested by the "pressure decay" method in accordance with AG-1, 2012 mandatory appendix TA-III, Article TAA-III-4200 and shall have a maximum leak rate of .0005 CFM per cubic foot of housing volume for 15 minutes.
- B BSL-3 Arrangement (installed on mounting base/stand)

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1. Inlet damper
2. Inlet transition
3. Prefilter / HEPA combination housing
4. Postfilter housing
5. Outlet transition
6. Outlet damper

C Radioisotope Arrangement (install on mounting base/stand)

1. Inlet damper
2. Inlet transition
3. Prefilter / HEPA combination housing
4. Carbon adsorber housing
5. Postfilter housing
6. Outlet transition
7. Outlet

2.8 FILTER GAUGES

- A Direct Reading Dial: 3-1/2 inch (90 mm) diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0 to 0.5 in-wc (0 to 125 Pa), 2 percent of full scale accuracy.

PART 3 EXECUTION

3.1 INSTALLATION

- A Install air cleaning devices in accordance with manufacturer's instructions.
- B Prevent passage of unfiltered air around filters with felt, rubber, or neoprene gaskets.
- C Install filter gauge static pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level.
- D Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with clean set.
- E Provide filter gauges on filter banks, installed with separate static pressure taps upstream and downstream of filters.

END OF SECTION 234000

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SECTION 235100
BREECHINGS, CHIMNEYS, AND STACKS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Double wall metal stacks.
- B Special gas venting.

1.2 RELATED REQUIREMENTS

1.3 REFERENCE STANDARDS

- A NFPA 54 - National Fuel Gas Code; 2024.
- B NFPA 82 - Standard on Incinerators and Waste and Linen Handling Systems and Equipment; 2024.
- C UL 1738 - Standard for Venting Systems for Gas-Burning Appliances, Categories II, III, and IV; Current Edition, Including All Revisions.

1.4 DEFINITIONS

- A Breeching: Vent connector.
- B Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- C Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.
- D Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

1.5 SUBMITTALS

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

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- B Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.
- C Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings. Submit layout drawings indicating plan view and elevations where factory-built units are used.
- D Manufacturer's Instructions: Include installation instructions, and indicate assembly, support details, and connection requirements.

1.6 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

2.1 SPECIAL GAS VENTING (CATEGORY II, III, AND IV)

- A Double-Wall Special Gas Venting:
 - 1. Manufacturers:
 - a. Heatfab Saf-T Vent: www.heatfab.com/#sle.
 - b. Z-Flex U.S. Inc: www.z-flex.com/#sle.
 - 2. Provide double-wall metal stacks, tested to UL 1738 and UL listed with positive pressure rating for use with building heating equipment; comply with NFPA 54.
 - 3. Fabricate with 1-inch (25 mm) minimum air space between walls and construct inner liner of 28-gauge, 0.015-inch (0.41 mm) 29-4C stainless steel minimum and outer jacket of 24 gauge, 0.025-inch (0.64 mm) stainless steel minimum.
 - a. Protect aluminized steel surfaces exposed to elements with minimum of one base coat of primer and one finish coat of corrosion-resistant paint suitable for outer jacket skin temperatures of application.
 - 4. Design, fabricate, and install gastight to prevent products of combustion from leaking into building. Securely connect inner joints and seal in accordance with manufacturer's instructions.
 - 5. Accessories, UL Labeled:
 - a. Rain/Stack Cap: Consists of conical rainshield with inverted cone for partial rain protection with low flow resistance.

PART 3 EXECUTION

3.1 INSTALLATION

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- A Install in accordance with manufacturer's instructions.
- B Assemble and install stack sections in accordance with NFPA 82, UL Listings, and industry practices. Join sections with acid-resistant joint cement. Connect base section to foundation using anchor lugs.
- C Level and plumb chimney and stacks.

END OF SECTION 235100

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SECTION 235216
CONDENSING BOILERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Manufactured units.
- B Boiler construction.
- C Boiler trim.
- D Fuel burning system.
- E Factory installed controls.

1.2 RELATED REQUIREMENTS

- A Section 033000 - Cast-in-Place Concrete.
- B Section 230913 - Instrumentation and Control Devices for HVAC.
- C Section 232114 - Hydronic Specialties.
- D Section 232500 - HVAC Water Treatment.

1.3 REFERENCE STANDARDS

- A AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); Current Edition.
- B ANSI Z21.13 - American National Standard for Gas-Fired Low-Pressure Steam and Hot Water Boilers; 2022.
- C 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.

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- D ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).
- E ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers; 2023.
- F NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); Current Edition.
- G NFPA 54 - National Fuel Gas Code; 2024.
- H SCAQMD 1146.1 - Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters; 1990, with Amendment (2018).

1.4 SUBMITTALS

- A Product Data: Provide data indicating general assembly, components, controls, safety controls, and wiring diagrams with electrical characteristics and connection requirements, and service connections.
- B Manufacturer's Installation Instructions: Indicate assembly, support details, connection requirements, and include start up instructions.
- C Manufacturer's Factory Inspection Report: Submit boiler inspection prior to shipment.
- D Manufacturer's Field Reports and Combustion Test Data
- E Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list, and maintenance and repair data.
- F Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 QUALITY ASSURANCE

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

1.6 DELIVERY, STORAGE, AND HANDLING

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- A Protect boilers from damage by leaving factory inspection openings and shipping packaging in place until final installation.

1.7 WARRANTY

- A Provide a ten (10) year non-prorated warranty to include coverage for heat exchanger against failure due to defects in materials or workmanship.
- B Provide a minimum twenty (20) year warranty for heat exchanger failure due to thermal shock
- C Provide a five (5) year warranty for the burner against failure due to defects in materials or workmanship.
- D All other components shall carry a one (1) year warranty from date of boiler start up.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Modular Condensing Hot Water Boiler for Indoor Applications:
 - 1. Cleaver Brooks Clearfire
 - 2. Fulton Endura Plus

2.2 MANUFACTURED UNITS

- A Factory assembled, factory fire-tested, self-contained, readily transported unit ready for automatic operation except for connection of water, fuel, electrical, and vent services.
- B Unit: Metal membrane wall, water or fire tube, condensing boiler on integral structural steel frame base with integral fuel burning system, firing controls, boiler trim, insulation, and removable jacket, suitable for indoor application.

2.3 BOILER CONSTRUCTION

- A Comply with the minimum requirements of ASME BPVC-IV and ANSI Z21.13 for construction of boilers.
- B Assembly to bear the ASME "H" stamp for 160 psi working pressure and comply with the efficiency requirements of the latest edition of ASHRAE Std 90.1 I-P.
- C Required Directory Listings:

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1. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.
 2. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); current edition at www.nationalboard.org.
- D Heat Exchanger: The heat exchanger shall be constructed of a fully welded 316L stainless steel and of fire tube design. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. There shall be no banding material, bolts, gaskets or "O" rings in the heat exchanger design.
1. Cast iron, aluminum, or condensing copper tube boilers will not be accepted.
- E Condensate Collection Basin: Fully welded 316L stainless steel.
- F Provide adequate tappings, observation ports, removable panels, and access doors for entry, cleaning, and inspection.
- G Insulate casing with insulation material minimum half inch thick mineral fiber, protected and covered by heavy-gauge metal jacket.
- H Factory apply boiler base and other components, that are subject to corrosion, with durable, acrylic, powder coated, painted, or weather-proofed finish.

2.4 BOILER TRIM

- A ASME rated pressure relief valve set at **75 PSIG**. Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
- B Flow switch.
- C Electronic Low Water Cut-off: Complete with test light and manual reset button to automatically prevent firing operation whenever boiler water falls below safe level.
- D Temperature and pressure gauge. Minimum 3-1/2 inch diameter. Pressure gage shall have normal operating pressure about 50 percent of full range.
- E Pressure Switches:
1. High gas pressure.
 2. Low gas pressure.
 3. Air pressure.

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- F Intake Filter and Dirty Filter Switch: Boiler shall include an intake air filter with a factory installed air pressure switch. The pressure switch will alert the end user on the screen of the boiler that the intake filter is dirty and needs to be changed.
- G Manual reset high limit.
- H Drain Valves: Minimum NPS 3/4 or nozzle size with hose-end connection.
- I Condensate Neutralization Kit: Factory supplied condensate trap with condensate trip sensor, high capacity condensate receiver prefilled with appropriate medium.

2.5 FUEL BURNING SYSTEM

- A Provide forced draft automatic burner or pulse combustion, integral to boiler, designed to burn natural gas, and maintain fuel-air ratios automatically.
 - 1. Blower Design: Statically and dynamically balanced to supply combustion air; direct connected to motor. Boiler shall be equipped with a pulse width modulating blower system to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The burner firing sequence of operation shall include pre-purge, firing, modulation, and post-purge operation.
 - 2. Forced Draft Design: Mixes combustion air and gas.
 - 3. Optional Pulse Combustion Design: Self-aspirating, not requiring blower for combustion.
 - 4. Combustion Air Filter: Protects fuel burning system from debris.
 - 5. Efficiency : **Achieve minimum 90 percent combustion efficiency at 50% firing rate with 120 degree return water.**
 - 6. The burner shall be high temperature stainless steel to provide modulating firing rates.
- B Gas Train: Plug valve, safety gas valve, gas-air ratio control valve, and pressure regulator controls air and gas mixture. The boiler shall be supplied with two gas valves designed with negative pressure regulation and shall be capable of a **minimum 5:1 turndown**.
- C Emission of Oxides of Nitrogen Requirements: Comply with SCAQMD 1146.1 for natural gas fired system, as applicable.
- D Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
- E Intakes: Combustion air intake capable of accepting free mechanical room air or direct outside air through a sealed intake pipe.

2.6 FACTORY INSTALLED CONTROLS

- A Option for internal or external (0-10) VDC control.

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- B The boiler shall have a built in Cascade controller to sequence and rotate lead boiler to ensure equal runtime while maintaining modulation of up to 8 boilers of different btu inputs without utilization of an external controller. The factory installed, internal cascade controller shall include:
1. Lead lag:
 2. Efficiency optimization: The Control module shall allow multiple boilers to fire at minimum firing rate in lieu of Lead/Lag.
 3. Front end loading:
 4. Rotation of lead boiler: The Control module shall change the lead boiler every hour for the first 24 hours after initializing the Cascade. Following that, the leader will be changed once every 24 hours.
- C Burner Operating Controls:
1. Set-Point Adjust: Set points shall be adjustable.
 2. Operating Pressure Control: Factory wired and mounted to cycle burner.
 3. Sequence of Operation: Factory installed controller to modulate burner firing rate to maintain system water temperature in response to call for heat.
 4. High Temperature Limit: Automatic and manual reset stops burner if operating conditions rise above maximum boiler design temperature. Limit switch to be manually reset on the control interface.
 5. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manually reset on the control interface.
 6. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
 7. High and Low Gas Pressure Switches: Pressure switches shall prevent burner operation on low or high gas pressure. Pressure switches to be manually reset on the control interface.
 8. Blocked Drain Switch: Blocked drain switch shall prevent burner operation when tripped. Switch to be manually reset on the control interface.
 9. Low air pressure switch: Pressure switches shall prevent burner operation on low air pressure. Switch to be manually reset on the control interface.
 10. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for any lockout conditions.
- D Temperature Controls with a DDC system:
1. Automatic reset type to control fuel burning system on-off and firing rate to maintain temperature.
 2. Manual reset type to control fuel burning system to prevent boiler water temperature from exceeding safe system water temperature.
 3. Low-fire start time delay relay.
 4. Boiler may be programmed to send a 0-10V DC output signal to an ECM or VFD boiler pump to maintain a designed temperature rise across the heat exchanger.
 5. Password Security: Boiler shall have a different password security code for the User and the Installer to access adjustable parameters.
 6. Service reminder: Boiler shall have the ability to display a yellow colored service notification screen based upon months of installation, hours of operation, and number of boiler cycles. All notifications are adjustable by the installer.

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7. BMS integration with 0-10V DC input: The Control shall allow an option to Enable and control set point temperature or control firing rate by sending the boiler a 0-10V input signal.
 8. Data logging: Boiler shall have non-volatile data logging memory including last 10 lockouts, hours running and ignition attempts and should be able to view on boiler screen.
- E Electronic PI setpoint/modulation control system.
- F Microprocessor-based, fuel/air mixing controls.
- G BAS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet MS/TP.
1. External Point Mapping: Provide mapping table for each parameter included in the local visual interface with software-toggle flag to allow reduced mapping of available points.
- H VENTING AND COMBUSTION AIR
1. Complete system, ASTM A959, Type 29-4C stainless steel pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
 2. The flue shall be capable of terminating at the sidewall or roof with the manufacturers specified vent termination.
 3. The air inlet pipe may be PVC or CPVC sealed pipe.
 4. The boiler's total combined air intake length shall not exceed 100 equivalent feet. The boiler's total combined exhaust venting length shall not exceed 100 equivalent feet.
- I ELECTRICAL POWER
1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.
 2. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 3. Voltage : See Drawings

2.7 SOURCE QUALITY CONTROL

- A Provide factory tests to check construction, controls, and operation of unit.
- B Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- C Manufacturer to conduct boiler inspection prior to shipment; submit copy of inspection report to Architect.

PART 3 EXECUTION

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3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install boiler and provide connection of natural gas service in accordance with requirements of NFPA 54 and applicable codes.
- C Install boiler on concrete housekeeping base, sized minimum of 4 inches (100 mm) larger than boiler base.
- D Coordinate factory installed controls with Section 230913.
- E Coordinate provisions for water treatment in accordance with Section 232500.
- F Pipe relief and drain valves to nearest floor drain.
- G Pipe cooled condensate produced by the combustion process from the boiler condensate connection and/or flue stack with suitable piping material to neutralizer prior to discharging into nearest floor drain.
- H Install electrical devices furnished with boiler but not specified to be factory mounted.
- I Install control wiring to field-mounted electrical devices.
- J Provide piping connection and accessories in accordance with Section 232114.
- K Install piping adjacent to boiler to allow service and maintenance.
- L Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
- M Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection.
- N Install flue venting kit and combustion-air intake. Connect full size to boiler connections.

3.2 FIELD QUALITY CONTROL

- A Perform tests and inspections and prepare test reports.

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1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Combustion Test including
 - a. Percent carbon monoxide.
 - b. Percent oxygen.
 - c. Percent excess air.
 - d. Flue gas temperature at outlet.
 - e. Ambient temperature.
 - f. Percent combustion efficiency.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
6. Remove and replace malfunctioning units and retest as specified above.

3.3 CLOSEOUT ACTIVITIES

- A Demonstrate proper operation of equipment to Owner's designated representative.

- B Demonstration: Demonstrate operation of system to Owner's personnel.

1. Use operation and maintenance data as reference during demonstration.
2. Briefly describe function, operation, and maintenance of each component.

- 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 235216

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SECTION 235700
HEAT EXCHANGERS FOR HVAC

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Plate type heat exchangers.

1.2 RELATED REQUIREMENTS

- A Section 230913 - Instrumentation and Control Devices for HVAC.
- B Section 232113 - Hydronic Piping.
- C Section 232114 - Hydronic Specialties.

1.3 REFERENCE STANDARDS

- A ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2023.

1.4 SUBMITTALS

- A Product Data: Provide data with dimensions, locations, and size of tapings and performance data.
- B Operation and Maintenance Data: Include start up and shut down instructions, assembly drawings, and spare parts lists.
- C Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

- A Protect internals from entry of foreign material by temporary caps on flanged openings.

1.6 WARRANTY

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- A Provide five year manufacturer warranty for heat exchanger.

PART 2 PRODUCTS

2.1 PLATE AND FRAME TYPE HEAT EXCHANGER

- A Manufacturers:
 - 1. AIC
 - 2. Armstrong Pumps Inc
 - 3. Tranter
 - 4. Bell & Gossett
 - 5. Alfa Laval
- B Comply with ASME BPVC-VIII-1 for manufacture of plate and frame type heat exchangers.
- C Frames: Carbon steel with baked epoxy enamel paint, stainless steel side bolts and shroud.
- D Plates: Stainless steel Type 304.
- E Gaskets: Nitrile rubber.
- F Nozzles: 125 psi (860 kPa) rated lined flange type.

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Install to permit removal of plates with minimum disturbance to installed equipment and piping.
- C Support heat exchangers on concrete housekeeping pad.
- D Pipe relief valves to nearest floor drain.
- E Pipe drain valves to nearest floor drain.

3.2 WATER TO WATER HEAT EXCHANGER TRIM

- A Water Inlets and Outlets: Thermometer wells, pressure gauge tapings.

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- B Heated Water Outlet: Thermometer well for temperature regulator sensor, ASME rated pressure and temperature relief valve, valved drain; see Section 232114.

END OF SECTION 235700

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SECTION 236426
ROTARY-SCREW WATER CHILLERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Air-cooled rotary-screw chiller.

1.2 RELATED REQUIREMENTS

- A Section 230593 - Testing, Adjusting, and Balancing for HVAC.
- B Section 230800 - Commissioning of HVAC.
- C Section 230923 - Direct-Digital Control System for HVAC.
- D Section 232113 - Hydronic Piping.
- E Section 232114 - Hydronic Specialties.

1.3 REFERENCE STANDARDS

- A AHRI 550/590 (I-P) - Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle; 2023.
- B ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2024, with Errata (2025).
- C 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.
- D ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2024, with Errata (2025).
- E ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels; 2023.
- F ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus; 2019.

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- G NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- H NEMA MG 00001 - Motors and Generators; 2024.
- I UL 984 - Hermetic Refrigerant Motor-Compressors; Current Edition, Including All Revisions.
- J UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A Product Data: Provide rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
- B Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.
- C Manufacturer's Instructions: Submit manufacturer's complete installation instructions.
- D Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- E Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories; include trouble-shooting guide.
- F Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

- A Comply with manufacturer's written installation instructions for rigging, unloading, and transporting units.
- B Deliver units to the job site completely assembled and charged with refrigerant and oil by manufacturer.

1.6 WARRANTY

- A Manufacturer's Warranty: Provide minimum one year warranty complete to include parts and labor.

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PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Trane Technologies
- B York, a brand of Johnson Controls International

2.2 AIR-COOLED, ROTARY-SCREW, WATER CHILLER CONSTRUCTION REQUIREMENTS

- A Factory assembled and tested chiller consisting of compressor(s), compressor motor(s), motor starter(s) or variable frequency drives as indicated, evaporator, condenser, enclosure, refrigeration circuits(s) and specialties, interconnecting piping, microprocessor-based controls, readouts, and diagnostics.
 - 1. Rating: AHRI 550/590 (I-P).
 - 2. Safety: ASHRAE Std 15 and UL 1995.
 - 3. Construction and Testing: ASME BPVC-VIII-1.
 - 4. Energy Efficiency: ASHRAE Std 90.1.
 - 5. Enclosures:
 - a. Structural Framing: Mount structural steel on welded steel base with hot-dip galvanized finish.
 - b. Steel Cabinet:
 - 1) Factory apply baked on powder paint or corrosion resistant paint prior to assembly.
 - 2) Provide gasketing and weatherproofing to panels with fully opening doors containing starters or variable frequency drives, terminal blocks, through-the-door type disconnects and circuit breaker with lockable handles indicating "power-on" or "power-off".
 - 3) Provide door stays.
 - c. Perform 500-hour salt spray test in accordance with ASTM B117 for outdoor applications.
- B Rotary-Screw Compressors:
 - 1. Unit: Semi-hermetic type with two, direct drive compressors with multiple independent refrigeration circuit(s), internal muffler, discharge, check, and suction service valves.
 - 2. Oil Lubrication System: Positive pressure system, oil heater, oil separator, check valves, solenoid valves, and filtration devices.
 - 3. Valves: Check valves in compressor discharge.
 - 4. Capacity Reduction System: Load/unload valve control down to 20 percent of full load without the activation of hot gas bypass.
 - 5. Motors: UL 984, 3,600 rpm, suction gas-cooled, hermetically sealed, squirrel cage induction with starter.
- C Evaporator, Shell and Tube Type:

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1. ASME BPVC-VIII-1, three pass type, with three independent refrigeration circuits.
 2. Shell, Removable Heads and Tube Support Sheets: Carbon steel.
 3. Tubes: Mechanically treated copper tubes fixed and aligned into intermediate tube support sheets across the shell to maintain consistent spacing between tubes with the capability of being cleanable.
 4. Working Pressure Rating, Refrigerant-Side: 200 psi (1380 kPa).
 5. Working Pressure Rating, Water-Side: 150 psi (1035 kPa).
 6. Cold Surface Insulation:
 - a. Factory install on shell and all other cold surfaces.
 - b. 0.75-inch (20 mm) minimum thickness, closed cell, expanded polyvinyl chloride flexible foam insulation with a maximum K factor of 0.28.
- D Provide vents and water drain connections.
- E Provide fittings for temperature control sensors.
- F Freeze Protection: Provide evaporator heater with thermostat to protect from freezing at ambient temperatures down to minus 20 degrees F (minus 28.9 degrees C).
- G Air-Cooled Condenser:
1. Heat Exchanger:
 - a. Arrangement: Two pass, round tubes.
 - b. Mechanically bond aluminum fins to internally enhanced, seamless copper tubing and protect with corrosion resistant materials or coatings.
 - c. Clean, dehydrate and test.
 - d. Leak Test: 506 psi (3490 kPa).
 - e. Seal: Nitrogen holding charge.
 2. Coil Guards: Provide expanded metal with lint screens. Protect condenser coil by enclosing with heavy plastic to prevent damage during shipping or rigging.
 3. Fans and Motors:
 - a. Dynamically balanced propeller type, direct drive fans of reinforced polymer corrosion resistant construction and equip with sealed, permanently lubricated ball bearings.
 - b. Discharge Fan Guards: Coated steel wire.
 - c. Discharge Direction: Vertical.
 - d. Motors: Totally enclosed, high efficiency, suitable for outdoor use, three phase, permanent split capacitor, single speed with internal overload protection.
- H Refrigeration Circuits:
1. Provide two independent refrigeration circuit(s) with two compressor(s) per circuit.
 2. Minimum Refrigerant Specialties per Circuit:
 - a. Isolation and service valves for refrigerant removal and charging.
 - b. Removable-core filter driers.
 - c. ASHRAE Std 15 compliant relief valves.
 - d. Liquid line sight glass with moisture indicator.
 - e. Refrigerant expansion valves or metering devices.

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- f. Complete operating charge of both refrigerant and oil.

I Starters and Drives:

- 1. Variable Frequency Drives: Completely assemble, wire, pipe, and factory test, factory or field mounted variable frequency drive (VFD). Limit the field electrical connections for compressor motor power to the main power leads to the VFD, wiring of liquid pumps and tower fans to the control panel.
 - a. Characteristics:
 - 1) Refrigerant cooled.
 - 2) Microprocessor based pulse width modulation (PWM) with input/output power devices, DC voltage rectifier, and inverter/control regulator to convert DC voltage to sinusoidal PWM waveform.
 - 3) Physically isolate low voltage control from main power sections.
 - 4) Control motor speed by integrated controls over wide range of operating conditions.
 - 5) Provide short circuit interrupt and withstand rating suitable for available current.
 - b. Performance:
 - 1) Full Load Efficiency: Minimum 97 percent at 100 percent VFD rated capacity.
 - 2) Unity Displacement Power Factor: 0.99 minimum.
 - 3) Voltage Boost Capability: Full motor voltage at reduced line voltage conditions.
 - 4) Soft start, linear acceleration, and coast to stop capabilities.
 - 5) Base Motor Adjustable Frequency Range: Control to 15 percent capacity at nameplate voltage.
 - 6) Torque Generation: 150 percent instantaneous.
 - c. Heat Sink and Mating Flange:
 - 1) Design for 185 psi (1276 kPa) waterside working pressure.
 - 2) Meter to maintain temperature within acceptable limits.
 - d. Suitable Ratings:
 - 1) Operation at plus or minus 10 percent nameplate voltage.
 - 2) Continuous Operation at:
 - (a) 100 percent of nameplate amperes and 5 seconds at 15 percent.
 - (b) Ambient temperature range of 40 to 122 degrees F (4 to 50 degrees C), 95 percent humidity noncondensing for altitudes up to 6,000 feet (1829 m).
 - 3) Comply with NEMA EN 10250 and NEMA MG 00001.
 - e. User Interface for Programming and Display of the Following Parameters:
 - 1) Operating, configuration and fault messages.
 - 2) Hertz frequency.
 - 3) VFD load, line side voltage, and current.
 - 4) kW.
 - 5) Input/output power devices temperature.
 - f. Electrical Service, Single Point Power:
 - 1) Input Circuit Breaker: Suitable for the available current indicated.
 - 2) Provide power for chiller oil pump via factory wired standard branch circuit breaker.

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- 3) Provide power for oil heater, VFD and controls via 3 kVA control power transformer and factory wired circuit breaker.
 - g. Discrete Dry-Contact Outputs:
 - 1) Circuit breaker shunt trip.
 - 2) Chilled water pump.
 - 3) Condenser water pump.
 - 4) Alarm status.
 - h. Analog Outputs: 4 to 20 mA for head pressure reference and condenser water control valve as applicable.
 - i. Provide protection for under/over-voltage, phase loss/reversal/unbalance, ground fault, single cycle voltage loss, programmable auto restart after power loss, and motor overload/over temperature protection.
- J Controls Package:
- 1. Unit Controls: Factory-supplied DDC:
 - a. Control-panel mounted with required input-output expansions, power supply, fused disconnect, hand switches, knobs, and accessories required to control chiller unit to manufacturer required sequences to meet intended use with listed performance.
 - b. Factory configured to interface prewired sensors, switches, and safeties with allowance to add up to four chiller valves and flow sensors.
 - c. Graphic-based touchscreen to include unit operation controls and user filter based interface for faults, alarms, performance, unit diagnostics, and data recording up to 12 months.
 - d. BAS, SCADA, or other Integrated Automation Link: ASHRAE Std 135 BACnet MS/TP.
 - e. External Point Mapping: Provide mapping table for each parameter included in the local visual interface with software-toggle flag to allow reduced mapping of available points.
 - f. Isolation Valves: Field-installed, 2-position, butterfly type with position tracking; see Section 253519.
 - 2. Control Components for Preventing Shutdown:
 - a. Provide high pressure limit with indicating light for each compressor, set lower than factory pressure switch to automatically unload compressor and prevent nuisance high pressure condenser control trip.
 - b. Provide one protector with indicating light for each compressor, with current limit setpoint of 120 percent of compressor running load amperage to automatically unload compressor preventing over-current trip.
 - c. Provide low refrigerant limit to automatically unload each compressor preventing a low evaporator temperature trip.
 - 3. Chiller Operation in Abnormal Operating Conditions:
 - a. Unloaded Running: Adequate chilled water production.
 - b. Trip-out Limit Reached: Chiller goes off-line and manual reset is required for continued operation.
 - 4. Control Panel Display:
 - a. Evaporator pressure.
 - b. Condenser refrigerant pressure.
 - c. Entering and leaving evaporator water temperature.

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5. Points for Remote Monitoring and Control:
 - a. Entering and leaving condenser water temperature as applicable.
 - b. Chilled water setpoint.
 - c. Electrical 3 phase current limit and percent RLA setpoint.
 - d. Electrical 3 phase amp draw.
 - e. Chiller operating mode.
 - f. Condenser refrigerant temperature.
 - g. Elapsed time and number of starts counter.
 - h. Chiller compressor run status relay.
 - i. Minimum of 20 diagnostics with time and date stamp.
 - j. Identification of the fault, date, time and operating mode at time of occurrence, type of reset required, and help message.
 - k. Relay output energized upon detecting a fault requiring manual reset.
 - l. Relay output energized whenever unit is operating in a limit mode for an extended period of time.
 - m. Analog input to control leaving chilled water temperature setpoint based upon a 4-20ma or 0-10 VDC signal from the building automation system.
 - n. Programmable soft during pull-down period via ramped current limit or fully adjustable, temperature pull-down rate.
 - o. Leaving chilled water reset based upon return water temperature.
 - p. Provide RS-232 for printer interface.

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Align chiller package on steel or concrete foundations.
- C Install units on vibration isolators.
- D Connect to electrical service.
- E Connect to chilled water piping.
- F Arrange piping for easy dismantling to permit tube cleaning and removal.
- G Coordinate BAS, BMS, or Integrated Automation linking between unit controller(s) and remote front end interface.

3.2 MANUFACTURER'S FIELD SERVICES

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- A Perform factory startup of the chiller by factory trained and authorized servicing technicians confirming equipment has been correctly installed prior to equipment becoming operational and covered under the manufacturer's warranty.
- B Supply initial charge of refrigerant and oil if not completely factory charged.
- C Demonstrate system operations and verify specified performance.

3.3 CLOSEOUT ACTIVITIES

- A 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 236426

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SECTION 237323
CUSTOM FABRICATED CENTRAL STATION AIR HANDLING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Casing construction.
- B Base construction.
- C Access doors.
- D Drain pans.
- E Direct drive fan section.
- F Motors.
- G Hydronic coils.
- H Fan inlet, exhaust air, and return air dampers
- I Integral outside airflow monitoring station / damper
- J Filter section.
- K Energy recovery wheel
- L Fan inlet airflow measuring

1.2 REFERENCE STANDARDS

- A ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015 (Reaffirmed 2020).
- B AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.

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- C AMCA 99 - Standards Handbook; 2016.
- D AMCA 204 - Balance Quality and Vibration Levels for Fans; 2020.
- E AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2016, with Errata (2018).
- F AMCA 300 - Reverberation Room Methods of Sound Testing of Fans; 2024.
- G AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2022.
- H AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2018.
- I AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; 2023.
- J ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- K 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.
- L ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- M NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- N NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.
- O SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- P AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001, with Addenda (2011).

1.3 SUBMITTALS

- A 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.

OEC - J20231537

CUSTOM FABRICATED CENTRAL STATION AIR HANDLING
UNITS
2025-10-17

237323 - 2

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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.
- B Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- C Manufacturer's Instructions: Include installation instructions.
- D Source quality-control reports.
1. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
 2. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."
 3. Water Coils: Factory tested to 300 psig (2068.43 kPa) according to ARI 410 and ASHRAE 33.
 4. Refrigerant Coils: Factory tested to 450 psig (3102.64 kPa) according to ARI 410 and ASHRAE 33.
- E Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
1. Provide three complete sets with descriptive literature, model, and serial number of all equipment; performance data; manufacturer's instructions for operating and maintenance; and lubrication recommendation.
- F Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra PreFilters (MERV9): two sets for each unit.
 2. Extra Filters (MERV14): one set for each unit.

1.4 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

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- C Comply with NFPA 70.
- D Each unit shall be selected with adequate fan assembly and casing construction so that it can operate in a stable condition (non-surfing and below its first critical speed) at the listed cfm with a static pressure 1.25 times the stated static pressure. This shall be borne out by published catalog data and fan curves.
- E The bidder and the unit supplier shall check plans carefully before bidding and again in the preparation and review of shop drawings to ensure that space available accommodates the proposed equipment in a manner to be accessible for service and components removal and replacement. Give special consideration to removal and replacement of filters, coils and other components.

1.5 FACTORY AND FIELD LEAKAGE AND FACTORY DEFLECTION TEST

- A Leakage Testing: The unit manufacturer shall factory and field pressure tests the air handling units. The leakage rate of the casing shall not exceed 1.0% of the unit air flow at +/- 10" static pressure.
 - 1. The test shall be conducted in accordance with SMACNA duct construction manual. A calibrated orifice shall be used to measure leakage airflow.
 - 2. An officer of the manufacturing company shall certify test results and forward copies of the certified test results to the engineer and owner.
 - 3. Positive pressure plenums shall be tested positively and negative pressure plenums shall be tested negatively.
 - 4. Units must be tested in a fully assembled as a complete assembled unit) state equal to that of operational equipment with unit sections mated and attached per Installation and Operation Manual instructions. AHU may not have temporary modifications, caulking, lubricant, tape, or another item designed to help it pass the test. Air handler doors will be closed using the factory locking mechanism normally supplied with the door, no additional blocking or modifications are allowed. Testing individual sections are NOT acceptable.
 - 5. Temporary panels may be used to secure all duct, damper and similar openings in the air handler.
- B Deflection Testing: The unit manufacturer shall provide factory deflection test for the air handling unit. The deflection shall be less than L/200 at +/- 10" static pressure.
 - 1. The test shall be conducted in accordance with SMACNA duct construction manual. A calibrated orifice shall be used to measure pressure.
 - 2. An officer of the manufacturing company shall certify test results and forward copies of the certified test results to the engineer and owner.
 - 3. Positive pressure plenums shall be tested positively, and negative pressure plenums shall be tested negatively.
 - 4. A dimensioned cross section of the units being tested showing the test locations must be provided to the University representative prior to test being performed.
 - 5. Deflection shall be measured using a laser.

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6. For each the test, either positive or negative, all points will be tested simultaneously. This typically involves at least three and no more than six points, one on the largest panel in each wall and the roof, one on a panel in the end wall, and two other points determined at the time of the test. The test point is typically at the midpoint of the cabinet height and midpoint of the width but at no point will the unit deflect more than specified. If, during testing, the witnessing University or Engineer representative observes excessive deflection in a panel other than that being tested the test will be repeated and the suspect panel tested in addition to any panel that failed the initial test. Panels that passed the initial test do not need to be retested.
7. Maximum allowable floor deflection is $L/400$ of the width of the floor being tested. Floor test with a 300 lb load on one square foot at the center of the floor.

1.6 FACTORY VIBRATION AND TESTING

- A Fans and motors shall be dynamically balanced to exceed a BV-4 criterion as per AMCA 204-96. The test shall be conducted after the fan and motor base assembly has been completed. The entire fan assembly including fan wheels, shafts, bearings, drives, belts, motors, isolation bases shall be tested. During the test, the fan and motor base shall be supported by its isolators which are set in the freely floating operating position. (In cases where a concrete inertia base is provided, the factory poured concrete shall be installed at the time of the vibration test).
- B The required measurement points are as follows: one horizontal measurement and one vertical measurement shall be taken for each fan and motor bearing and one axial measurement shall be taken for each shaft. The measurements shall be taken using calibrated, magnetically mounted accelerometers and a calibrated measuring instrument.
- C Vibration measurement locations shall be as close as possible to the bearing or shaft centerlines. Measurements shall be taken from the bearing housings, bearing pedestals, or motor casings. Measurements shall not be taken from flexible covers or shields.
- D Fans and motors shall be tested at the design RPM and the maximum overall filter-in vibration levels at each measurement point shall be less than or equal to 0.15 inch (3.81 mm) /second peak velocity at the operating speed. If any measurements exceed the above criterion, the assembly shall be rebalanced and re-tested until the criterion is achieved.
- E Certified measurements shall be provided to the owner and engineer.

1.7 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.

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- 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.

1.8 WARRANTY

- A Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Haakon Industries
- B Ingenia, Technologies
- C Air Flow Equipment
- D Air Enterprises LLC

2.2 MANUFACTURERD UNIT

- A General Description: Factory-assembled, minimum 4-inch solid double wall unit consisting of fan motors and drive assembly, coils, dampers, plenums, filters, sound attenuators, and condensate pans.

2.3 CASING CONSTRUCTION

- A Walls and roofs shall be constructed of minimum of 16-gauge galvanized steel minimum acoustic thermal panels. Panel thickness shall be minimum 4". The inner liner shall be minimum of 18- gauge wash-down aluminum liner in all sections except the chilled water coil sections. The chilled water and humidifier section shall be wash-down stainless steel liner. Insulation shall be a minimum of 4", 3 lbs density fiberglass. Minimum casing R-value=18. Insulation shall meet flame spread rating of less than 25 and a smoke developed rating of less than 50 when measured in accordance with ASTM E84. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 1/8" x 3/8" tape sealer. Tape sealer shall be LEED qualified. Wall (and roof) seams shall be turned inward to provide a clean flush exterior finish. All panel seams shall be sealed during assembly to produce an airtight unit.

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- B Foam panel construction shall be constructed of minimum 18-gauge galvanized steel on the exterior. the inner liner shall be minimum of 22-gauge wash-down aluminum liner in all sections except the chilled water coil section. Panel thickness shall be minimum 3". The individual panels shall be insulated with injected hydrophobic polyurethane foam. The chiller water coil and humidifier section shall be wash-down stainless steel liner. The insulation shall be a minimum of 3", injected hydrophobic polyurethane foam. The minimum casing R-value=19.5. Insulation shall meet flame spread rating of less than 25 and a smoke developed rating of less than 50 when measured in accordance with ASTM E84. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 1/8" x 3/8" tape sealer. Tape sealer shall be LEED qualified. Wall and roof seams shall be turned inward to provide a clean flush exterior finish. All panel seams shall be sealed during assembly to produce an airtight unit.
- C Internal liner shall be suitable for washing with a pressure washer or steam cleaned without risk of wetting the insulation. The liner shall be installed over top of the panel flanges and each liner seam shall be sealed with a lap joint. The wall liner shall be installed over top of the base water dam such that any water run-off from the liner will drip into the watertight base rather into the wall panel. The roof liner shall be installed over top of the roof support so that water cannot enter the roof insulation.
- D Under scheduled supply air temperature and design conditions on the exterior of the unit, condensation shall not form on the casing exterior (doors included).
- E The unit shall have roof panels broken outward to provide a lapped joint watertight seal. Roofs shall be sloped, one direction.
- F All insulation edges shall be joined on 8" centers using zinc plated TEK screws, bolts or metal clinches.
- G All insulation edges shall be protected with metal lagging. Insulation systems using stickpins or adhesives are not acceptable.
- H Stiffeners of angle steel shall be supplied as required to maintain casing deflection criteria of 1/200 at 10" of static pressure. If panels cannot meet this deflection, add additional internal reinforcing.
- I All vertical panels shall be sealed from the inside and internally thermally broken. No external screws exposed on the exterior on the vertical seems.

2.4 BASE CONSTRUCTION

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- A Base shall be constructed from structural steel channel around the perimeter of the unit, with intermediate channel and angle supports. Units shall have a minimum 8" base. Base steel shall be primed and painted on both the inside and outside. Base shall be continuously welded at all seams.
- B A minimum of 3/16" thick aluminum checker plate floor shall be installed on the base. Floor shall be flat reinforced from below, with all seams continuously welded. Drive screw or bolt attachment and caulking are not acceptable. Base shall be provided with lifting lugs, minimum four (4) per unit section. The base shall be insulated with a minimum of 3" spray foam insulation sheeted with a 22-gauge galvanized steel liner. Floors that "oil can" are not acceptable.
- C Provide a 1.5" perimeter collar around the entire unit, and around each floor opening to ensure the unit is internally watertight. The entire base shall act as an auxiliary drain pan and hold up to 1.5" of water. The perimeter collar shall be continuously welded to the floor plate.
- D Provide auxiliary 1.25" aluminum drains in each section except the chilled water coil section. The chilled water coil section will have a drain pan and stainless steel condensate connection.
- E Maximum base deflection shall be 1/4" on 240" unsupported span.
- F All floors shall be flat including sections of washdown construction.

2.5 ACCESS DOORS

- A Access doors shall be manufactured from minimum of 16-gauge galvanized steel for the outer skin. The doors shall be double wall construction with 18-gauge solid aluminum liner on the inside all sections except for the chilled water section. The chilled water coil sections shall be 304 stainless steel inner liner. Corners of the doors shall be continuously welded for rigidity. Insulation shall be 4" thick - 3 lb/cu ft. density fiberglass. Doors must be the same thickness as the unit casing to maximize thermal and acoustical resistance. Hinges shall be continuous piano type stainless steel.
- B Two chrome plated "Ventlok" Model #310 high pressure latches operable from either side of the door shall be provided. (PLASTIC DOOR HANDLES ARE NOT ACCEPTABLE) Door opening shall be fully gasketed with continuous 1/2" closed cell hollow round black gasket with a metal encapsulated reinforcing backing that mechanically fastens to the door frame. Door frames shall be made from 16-gauge galvanized steel with the outside size of the door flush with the unit. Minimum door opening size shall be 24" x 70" (where height permits). Fan compartments must have a door of minimum width to remove the motor or the largest component.
- C All access doors must swing against the air pressure (i.e. positive pressure plenum doors must swing in) and must be fully gasketed.

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- D All access doors shall be provided with Metal Test Ports for unit air stream for testing in each plenum section between each component with the AHU.
- E Provide windows which are at a minimum 10" X 10" or 12" diameter double pane safety vision in all access doors.

2.6 DRAIN PANS

- A Drain Pans: Readily cleanable, formed sections of stainless steel sheet complying with ASHRAE Standard 62. Fabricate pans in sizes and shapes to collect condensate from cooling coils (including coil piping connections and return bends) when units are operating at maximum catalogued face velocity across cooling coil. Pans shall be sloped in two planes for complete drainage to a single outlet without standing water. The drain pans at floors shall be depressed below the air handler floor level to prevent overflow.
 - 1. Double-Wall Construction: Fill space between walls with minimum of 4-inches insulation and seal moisture tight.
 - 2. Drain Connection: Same side of unit as coil connection side, unless noted otherwise; pre-piped to exterior of unit.
 - 3. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil. Provide stainless steel intermediate drain pans that extend a minimum 3" downstream of coil face. Provide multiple 1" stainless steel condensate piping from intermediate pan to main drain pan. All portions of the drain pan, including intermediate pans and any hardware subject to contact with condensate, shall be constructed of Type 304 stainless steel.
 - 4. Fasteners: All fasteners exposed to weather shall be corrosion resistant.
 - 5. Drain pans shall extend a minimum of 4" upstream and a minimum of 18" downstream of the cooling coil.
 - 6. All drain pans shall have removalable 304 stainless steel walk on grating.

2.7 DIRECT DRIVE FAN SECTION

- A Fan-Section Construction: Fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels.
 - 1. Mount fan and motor on an internal, fully welded, rigid structural steel base. Base shall be free floating at four corners on housed spring vibration isolators, minimum 2-inch static deflection. Vibration isolators shall be Mason Industries Model SLF or equal.
 - 2. Hoist Rail: Provide I beam hoist rail above fan section access doors to remove motors of 15hp and above. An extendable arm shall be provided to transport the motor to the unit exterior. Hoist rail shall be supported off of the flooring system of the unit.

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- B Fans, General: All fans shall be direct drive plenum style including aluminum wheels, with continuously welded blades, with smooth-curved inlet flange, heavy back-plate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and back-plate; cast-iron or cast-steel hub riveted to back-plate and fastened to shaft with set screws.
- C Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.
- D Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - 1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - 2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- E Plenum fan assembly must have an enclosed safety screen as per OSHA Standards.
- F Fans shall have inlet OSHA approved inlet screens.
- G Fans shall be selected at a maximum of 60 Hz and shall not exceed 60 Hz at peak load.
- H Vibration test all fans at design rpm BV-4 requirements. Maximum allowed movement in any 3 planes is 0.15"/sec.

2.8 MOTORS

- A General: Refer to Division 23 Section "Electrical Requirements For HVAC Equipment" for general requirements, which are fully applicable to the work of this Section as if repeated herein.
- B Motor Sizes: Minimum size as indicated, but larger if necessary so driven load will not require motor to operate in service factor range at design point, and larger if necessary so driven load will not require motor to operate beyond the service factor at any point on the fan curve. Motor HP must be at least 1.15 times BHP.
- C Location: Motor, drive, and access door shall be on the same side of the fan as the coil connection side, unless otherwise indicated. Provide motor on an adjustable base, inside the air handling unit housing. Motors external to the air-handling unit housing are not acceptable.
- D Inverter-Duty or Inverter-Ready Motors are required for all fans indicated to be controlled by a variable frequency drive.

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- E Noise Rating: Quiet.
- F Provide an Aegis shaft grounding kit for all motors.
- G Motors shall have extended lube lines.
- H Motor bearing life shall be L10-100,000 hours.

2.9 HYDRONIC COILS (HOT WATER, CHILLED WATER COILS AND HUMIDIFIER)

- A Coil Sections: Individual, insulated casings for cooling coil. Design and construct to facilitate removal and replacement of coil for maintenance and to assure full airflow through coils.
- B Chilled Water Cooling Coils: Comply with all requirements specified herein for cooling coils.
- C Coil Casing: Cooling coils shall be all stainless steel materials. The hot water coil shall have galvanized steel casing.
- D Circuit Arrangement: Self-draining and self-venting coil fabricated according to AHRI 410. Number of rows shall be determined by manufacturer to meet scheduled performance requirements. Unless noted otherwise, do not exceed 2 rows for heating coils or 12 rows for cooling coils.
- E Piping Connections: Threaded or flanged, on same side. Coil connections shall be on the side of the unit indicated on the Drawings. Coil connections shall extend 4" outside of casing for ease of connection.
- F Tubes: Copper, 5/8-inch O.D. with 0.035-inch minimum wall. Select coils for not less than 2 fps water velocity and not more than 6 fps water velocity.
- G Fins: Aluminum of minimum thickness 0.075-inch. Spacing shall not exceed 10 per inch for cooling coils.
- H Fin and Tube Joint: Mechanical bond created via thermal expansion.
- I Headers: Non-ferrous, such as seamless copper tube with brazed joints, with drain and air vent tapplings. Headers and return bends shall be enclosed within the air handling unit casing.
- J Frames: Stainless steel, 0.0625-inch is required for cooling coils. Galvanized-steel channel frame, 0.052-inch is acceptable for heating coils.

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- K Ratings: Design tested and rated according to ASHRAE 33 and AHRI 410.
- L Working-Pressure Ratings: 200 psig (1378.95 kPa), 325°F.
- M Source Quality Control: Test to 300 psig (2068.43 kPa) and to 200 psig (1378.95 kPa) underwater

2.10 FAN INLET, EXHAUST AIR, AND RETURN AIR DAMPERS

- A Furnish and factory-install integral air dampers within air handling units.
- B Aluminum airfoil frames and blades shall be a minimum of 12 gauge extruded aluminum. Blades shall be of a single unit airfoil design 6" wide.
- C Frames shall be extruded aluminum channel with grooved inserts for vinyl seals. Standard frames: 2" x 4" x 5/8" on linkage side, 1" x 4" x 1" on the other 3 sides.
- D Pivot rods shall be 7/8" hexagon extruded aluminum interlocking into blade section. Bearings shall be of a double sealed type with a Celcon inner bearing on a rod within a Polycarbonate outer bearing inserted into frame so that the outer bearing cannot rotate.
- E Bearing shall be designed so that there is not metal-to-metal or metal-to-bearing riding surfaces. Interconnecting linkage shall have a separate Celcon bearing to eliminate friction in linkage.
- F Blade linkage hardware shall be installed in frame out of air-stream. All hardware shall be on non-corrosive, reinforced material of cadmium plated steel.
- G Damper seals shall be designed for minimum air leakage by means of overlapping seals.
- H Jack shaft assemblies shall be provided for multiple damper installations.
- I Dampers shall be TAMCO 1000 or equal for Return Dampers.
- J Dampers shall be TAMCO 7600 CW or equal for Fan Inlet Dampers for Fan Array Operation.
- K Dampers shall be TAMCO 9000 Insulated Dampers or equal for outdoor air, relief air and exhaust air.

2.11 INTEGRAL OUTSIDE AIRFLOW MONITORING STATION / DAMPER

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- A An integral air monitor and damper assembly shall maintain a minimum outside air volume. The integral air monitor/damper shall incorporate air-measuring ports built into the damper blades and shall control the amount of outside air. The construction of the air monitor/damper shall be 0.125-inch aluminum U-channel frame 6-inch wide. The sensing blades shall be 5 inches (127 mm) wide, heavy gauge airfoil type with an anodized finish. Jamb seal's shall be stainless steel compression type and linkage shall be concealed out of the air stream within the damper frame to reduce pressure drop, noise and maintenance.
- B The IAQ damper assembly shall include 24 VAC electric modulating motor and DDC controller. The integral air monitor/damper shall be individually calibrated in an AMCA Registered laboratory and a corresponding airflow chart shall accompany the air monitor/damper.
- C The integral air monitor/damper shall be TAMCO, Ebtron Air, or CRC.
- D Shall be provided on minimum outdoor air damper only.

2.12 FILTER SECTION

- A Pre-filters: Filter Section: Pre Filters shall be MERV 9 pleated, disposable types. Each filter shall consist of a non-woven cotton and synthetic fabric media, media support grid and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2.
 - 1. Pre-filters shall be installed in prefabricated channel rack.
 - 2. Pre-filters shall be lift-out where access is available upstream of the filter or slide out when access is not available. Provide vertical blockoffs at filter seams to prevent air bypass when filters are loaded.
 - 3. Prefilters shall be equal to AAF PerfectPleat HC M8 or equivalent Camfil.
- B Final filters shall be MERV 14 high performance, deep pleated, totally rigid and disposable type. Each filter shall consist of high density microfine glass fiber media, media support grid, contour stabilizer and enclosing frame.
 - 1. Final filter media shall be of high density microfine glass fibers that are laminated to a non-woven synthetic backing to form a lofted filter blanket. The filter media shall have an average efficiency of 90-95% on the ASHRAE Test Standard (52-76) and a MERV 14 rating. It shall have an average arrestance of not less than 99% on that standard. Filters shall be listed by Underwriters' Laboratories as Class 2.
 - 2. Holding Frames: Holding frames shall be factory fabricated of 16-gauge galvanized steel and shall be equipped with gaskets on all 4 sides of the filter and 2 heavy duty positive sealing fasteners. Each fastener shall be capable of withstanding 25 lbs. pressure without deflection and be attached or removed without the use of tools.
 - 3. Final Filters shall be lifted out where access is available upstream of the filter. Side slideout filters are not acceptable.
 - 4. Low pressure drop v-bank air filters with a clean air pressure drop of 0.32" at 500 FPM
 - 5. Final filters shall be equal to AAF Varicel VXL or equivalent Camfil.

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- C Provide Dwyer 2000 (photohelic) magnehelic gauge. The gauge shall be accurate to $\pm 2\%$ of full range. One gauge shall be provided for each filter bank. Gauges shall be recessed into cabinet casing.

2.13 ENERGY RECOVERY WHEEL

- A Energy Recovery Wheel Construction:
 - 1. Energy recovery wheels shall be manufactured of corrugated aluminum treated for corrosion resistance and shall include a ion exchange resin desiccant to adsorb and transfer humidity in the vapor phase while avoiding adsorption and transfer of typical ambient non-water vapor molecules.
 - 2. The aluminum element and desiccant shall be treated with an EPA registered bacteriostatic agent capable of inhibiting growth or reproduction of bacteria on the wheel. Wheels shall be capable of cleaning by soft brush, vacuum-cleaner or low-pressure compressed air.
 - 3. Wheel surfaces shall be smooth to provide consistent seal gap between the wheel face and the cassette seal ring for the multi-pass seal.
 - 4. Wheels of more than 60 inches (1524 mm) in diameter shall be of segmented construction with the wound element cut into pie shapes which are bolted together to form the wheel. Each pie shaped element shall be held in place by a structural encasement formed of corrosion resistant coated steel which surrounds the cut.
 - 5. The encased pie segments shall be bolted to the hub, to each other and to the periphery rim. Each joint shall be sealed with high grade weather resistant low vapor emitting caulking to prevent air from bypassing the element.
- B The cassette of the rotary heat exchanger shall have a built-in adjustable purge section providing a minimum cross contamination of exhaust air to the supply air. The purge angle and purge air volume shall be determined by the manufacturer considering the air face velocity, the wheel rotational speed and the differential air pressure between the entering outside air and the entering exhaust air streams at the respective wheel face.
- C Purge shall be complete with an adjustable built-in purge section to limit carry-over of exhaust air to the supply air stream to 0.04% when operated under design conditions. The purge plate shall be mounted to a pivot and locked into position by secure fasteners for quick field adjustment. A multi-pass seal shall be installed on the swing arm similar to the seals described below. Rotation of the wheel shall be in the direction from the return air through the purge to the supply air side.
- D Seals of the supply and exhaust air stream shall be isolated from each other by means of adjustable multi-pass seals secured to the cassette panels and air separator tube. Multipass seals shall consist of a non-contact four or eight finger labyrinth seal. The selection of the seal shall be based on the differential pressure between the supply air plenum and the return plenum as measured in proximity to the wheel face. Multi-pass seals shall be installed with a 0.08 inch (2 mm) gap between the seal and the wheel flange.

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- E All non-galvanized metal parts exposed to the air streams shall be painted with a minimum of one coat of primer and one coat of corrosion resistant paint.
- F Wheel support and bearings: The energy recovery wheel shall be shaft mounted and supported by externally mounted pillow block ball bearings supported by the cassette frame. The pillow block bearings shall be provided with a grease fitting. The pillow block bearings shall be mounted to allow convenient service and replacement without the removal of the energy recovery wheel from the cassette.
- G Wheel drive system: The wheel shall be driven by a V-belt installed around the outside of the wheel. A gear motor, pulley and belt tensioner shall be installed and sized to drive the wheel through its complete speed range for all seasons and speed control sequences. The gear-motor shall be VFD-rated for variable speed operation. The gear-motor shall be factory mounted in the bottom section of the cassette.
- H Acceptable manufacturers are SG America, Semco and Thermotec.

2.14 FAN INLET AIRFLOW MEASURING

- A Provide an airflow piezometer measuring probes for each fan capable of continuously monitoring the air handling capacity of the respective fans.
- B Each piezometer airflow probes shall contain multiple, averaged velocity pressure taps located symmetrically around the throat of the fan inlet(s) and a single static pressure tap located on the fan housing. The entire airflow monitoring probe must be located outside the inlet throat as to not obstruct the airflow. Provide interconnecting tubing and single connection point for transducer. Interconnecting tubing shall be mounted outside the inlet throat.
- C The piezometer probes shall be capable of producing steady, non-pulsating signal of the velocity pressure, independent of the upstream static pressure without adversely affecting the performance of the fan. The sensing probes shall be accurate to 5 percent of actual fan airflow.
- D Provide differential pressure versus airflow calibration curves and equations. The air handling unit manufacturer shall provide the transducer with LCD screen to display CFM. Supply voltage shall be 24 VAC and output signal shall be 4-20 mA. Provide BACNET IPconnection to building automation system.
- E Fan inlet airflow measure shall be manufactured by air handling unit manufacturer or by Ebtron or CRC.

2.15 FINISH

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- A Unit shall be finished painted with two components, etch bond primer and finish painted with alkyd enamel, the color shall be selected by the architect. All uncoated steel shall be painted with grey enamel. All metal surfaces shall be pre-painted with vinyl wash primer to ensure paint bonds to metal. All paint shall be suitable for outdoor installation.

2.16 ELECTRICAL

- A Factory wire and test all air handling units. by CSA, ETL or UL.
- B Unit manufacturer shall provide non-fused disconnect for single point power connection for the air handling unit. The disconnects shall be mounted on drive side of air handling unit. Factory wire from the main disconnect to each VFD. Wiring and devices shall comply with the NEC. All wiring shall be concealed in conduit, provide junction boxes as required.
- C Provide main circuit breaker for entire unit. Downstream of the main unit circuit breaker, there shall be individual breakers for each fan VFD's, energy wheel VFD, light GFI circuit and (4) 120V spares.
- D Unit manufacturer shall receive VFDs from TCC and install VFD's for all fan motors.
- E Unit manufacturer shall provide, install, and wire the complete electrical system and all branch circuit wiring and conduit.
- F Label and number code all wiring and electrical devices in accordance with the unit electrical diagram. Mount the devices in a control panel inside the unit's service enclosure or on the outside. Ensure the control panel meets the CSA, ETL or UL.
- G Marine Lights in Airstream: Each section which includes an access door shall also include a factory-mounted, enclosed and gasketed, vapor-tight, LED light fixture. Include junction box, globe, aluminum globe guard, receptacle, and bulb ready for field wiring. 60 minute timer switch shall be provided for the lights. Provide lights where shown on the drawings, minimum of two lights in each section.
- H GFCI Receptacle: Provide duplex GFI receptacle; 20 amp / 120 volt, on the unit exterior. The exterior receptacle shall be weatherproof.
- I Provide a completely empty run of control conduit. Access to be via a junction box in the service corridor.

PART 3 EXECUTION

3.1 INSTALLATION

OEC - J20231537
CUSTOM FABRICATED CENTRAL STATION AIR HANDLING
UNITS
2025-10-17

237323 - 16

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- A Unit shall be mounted on a concrete pad as shown on the drawings. Coordinate location and dimensions of the unit and mounting elements with other trades.
- B Install flexible duct connections between fan inlet and discharge ductwork and air handling unit sections. Ensure that metal bands of connectors are parallel with minimum 1 inch (25.4 mm) flex between ductwork and fan while running.
- C Make connections to coils with unions or flanges.
- D Hydronic Coils:
 - 1. 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.

3.2 WIRING

- A All power wiring shall be run in conduit and comply with the N.E.C., including flexible type at motor connections.

3.3 DRAIN

- A Condensate drain piping with a deep trap from the drain pan to the designated discharge point shall be provided.

3.4 START-UP

- A Start-up shall be provided, supervised by the unit manufacturer or a manufacturer certified service organization. Physical connections shall also be provided. Provide supervision for as long a period of time as is necessary to ensure proper operation of the unit but in no case for less than 2 full working days. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made. Submit a written report to the Owner and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.
- B Final checks before start up: Perform the following:
- C Verify that shipping, blocking, and bracing are removed.

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1. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
2. Perform cleaning and adjusting specified in this section.
3. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
4. Lubricate bearings, pulleys, belts, and other moving parts with factory recommended lubricants.
5. Set zone dampers to fully open position for each zone.
6. Comb coil fins for parallel orientation.
7. Install clean filters.
8. Verify that manual and automatic control and fire dampers in connected duct systems are in fully open position.

D Starting procedures for air handling units include the following:

1. Energize motor, verify proper operation of motor, drive system, and fan wheel.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.5 CLOSEOUT ACTIVITIES

A Demonstration: Demonstrate operation of system to Owner's personnel.

1. Use operation and maintenance data as reference during demonstration.
2. Conduct walking tour of project.
3. Briefly describe function, operation, and maintenance of each component.

B 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.

C CLEANING

1. Unit to be flushed, cleaned and new filters installed prior to turning over to Owner.

END OF SECTION 237323

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SECTION 238200
CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Hydronic finned tube radiation.
- B Hydronic unit heaters.
- C Hydronic cabinet unit heaters.
- D Fan-coil units.
- E Hose kits and Valves

1.2 RELATED REQUIREMENTS

- A Section 230913 - Instrumentation and Control Devices for HVAC.
- B Section 232113 - Hydronic Piping.
- C Section 232114 - Hydronic Specialties.

1.3 REFERENCE STANDARDS

- A AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); Current Edition.
- B AHRI 440 - Performance Rating of Room Fan-Coils; 2008.
- 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 NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2024.

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F SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.

1.4 SUBMITTALS

- A Product Data: Provide typical catalog of information including arrangements.
- B Shop Drawings:
 - 1. 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.
- C Selection Samples: For each finish product specified, color chart representing manufacturer's full range of available colors.
- D Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.

1.5 WARRANTY

- A Provide 5 year manufacturer's warranty.

PART 2 PRODUCTS

2.1 HYDRONIC FINNED TUBE RADIATION

- A Manufacturers:
 - 1. Modine Manufacturing Company
 - 2. Slant/Fin Corporation
 - 3. Zehnder Rittling
- B Required Directory Listing: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.
- C Heating Elements: 3/4 inch (20 mm) ID seamless copper tubing, mechanically expanded into evenly spaced aluminum fins suitable for soldered fittings.
- D Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.
- E Enclosures: Refer to architectural details for custom enclosure.

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- F Finish: Factory applied baked primer coat.
- G Damper: Where not thermostatically controlled, provide knob-operated internal damper at enclosure air outlet.
- H Access Doors: For otherwise inaccessible valves, provide factory-made permanently hinged access doors, 6 by 7 inch (150 by 175 mm) minimum size, integral with cabinet.

2.2 HYDRONIC UNIT HEATERS

- A Manufacturers:
 - 1. Modine Manufacturing Company
 - 2. Sterling Hydronics, a Mestek Company
 - 3. Trane Technologies, PLC
- 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 (1.21 mm) thick sheet steel casing with threaded pipe connections for hanger rods for horizontal models and minimum 18 gauge, 0.0478 inch (1.21 mm) 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.

2.3 HYDRONIC CABINET UNIT HEATERS

- A Manufacturers:
 - 1. Modine Manufacturing Company
 - 2. Sterling Hydronics a Mestek Company
 - 3. Trane Technologies, PLC

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- B Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for purpose indicated.
- C Coils:
 - 1. Evenly spaced aluminum fins mechanically bonded to copper tubes.
- D Cabinet: Minimum 16 gauge, 0.0598 inch (1.52 mm) thick sheet steel front panel with exposed corners and edges rounded, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles.
- E Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- F Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- G Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- H Control: Factory wired, solid state, infinite speed control, located in cabinet.
- I Filter: Easily removed, 1 inch (25 mm) thick glass fiber throw-away type, located to filter air before coil.

2.4 FAN-COIL UNITS

- A Manufacturers:
 - 1. Carrier Corporation
 - 2. Daikin Applied
 - 3. Krueger-HVAC
 - 4. Trane Technologies
 - 5. Multiaqua
- B Performance Data and Safety Requirements:
 - 1. Unit capacities certified in accordance with AHRI 440.
 - 2. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for purpose indicated.
 - 3. Insulation to comply with NFPA 90A requirements for flame spread and smoke generation.
 - 4. Equipment wiring to comply with requirements of NFPA 70.
- C Required Directory Listings: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI).

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- D Coils:
1. Evenly spaced aluminum fins mechanically bonded to copper tubes.
 2. Water Coil: Suitable for working temperatures not less than 200 degrees F (93 degrees C).
 3. Provide drain pan under cooling coil easily removable for cleaning.
- E Horizontal Recessed Units:
1. Provide with a galvanized steel cabinet, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles with minimum 18 gauge, 0.0478 inch (1.21 mm) thick sheet steel bottom panel.
 2. Ducted Units: Provide with air inlet and outlet duct collars.
- F Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- G Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- H Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- I Controls:
1. Provide units with control valves furnished by the fan coil unit manufacturer.
- J Filter: Easily removed 1 inch (25 mm) thick glass fiber throw-away type, located to filter air before coil.

2.5 HOSE KITS AND VALVES

- A Manufacturers:
1. Griswold Controls
 2. Hays Fluid Controls
 3. IMI Flow Design, a brand of IMI Hydronic Engineering Division of IMI PLC
- B Hoses:
1. Provide hoses for all units for connection to main water supply and return headers.
 2. Length: 2 feet (0.61 m).
 3. Material: Braided stainless steel rated to minimum 400 psi (3,758 kPa) at 265 degrees F (129.4 degrees C).
- C Ball Valves:
1. Brass body for shutoff and hydronic balancing.
 2. Provide memory, memory stop, and pressure/temperature ports.

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D Y Strainers:

1. Bronze body.
2. "Y" type configuration with brass cap.
3. Maximum Operating Pressure: Minimum 450 psi (3103 kPa).
4. Screen: Stainless steel.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that surfaces are suitable for installation.
- B Verify that field measurements are as indicated on drawings.

3.2 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 Finned Tube Radiation:
1. Locate on outside walls and run cover continuously wall-to-wall unless otherwise indicated.
 2. Center elements under window with elements of equal length centered under each window for multiple windows.
 3. Install wall angles and end caps where units butt against walls.
 4. Align cabinet joints with window mullions.
 5. Install wall angles where units butt against walls and align cabinet joints with window mullions.
- 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.
- E Fan-Coil Units:
1. Install as indicated.
 2. Coordinate to ensure correct recess size for recessed units.
- F Units with Hydronic Coils:
1. Provide with shut-off valve on supply piping and tamper-proof, balancing valve with memory stop on return piping.

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2. If not easily accessible, extend air vent to exterior surface of cabinet for ease of servicing.
3. Provide float operated automatic air vents with stop valve for cabinet unit heaters, fan coil units, and unit heaters.

G Units with Cooling Coils: Connect drain pan to condensate drain.

H Air Coils:

1. Install in ducts and casings in accordance with SMACNA (DCS).
 - a. Support coil sections independent of piping on steel channel or double angle frames and secure to casing.
 - b. Provide frames for maximum of three coil sections.
 - c. Arrange supports to avoid piercing drain pans.
 - d. Provide airtight seals between coil and casing or duct.
2. Coil Safeguards:
 - a. Protect coils to prevent damage to flanges and fins.
 - b. Comb out damaged fins.
3. Install all coils level except cleanable coils with 1:50 pitch.
4. Make connections to hydronic and steam coils with unions and flanges.
5. Hydronic (Drainable) Coils:
 - a. Connect water supply to leaving air side of coil (counterflow arrangement).
 - b. Provide with shut-off valve on supply piping and tamper-proof, balancing valve with memory stop on return piping.
 - c. Locate supply water connection on leaving air side at bottom of supply header, and return water connection at top.
 - d. Provide manual air vents with stop valves at high points.
 - 1) Install drain connections at low points of installation.
6. Cooling Coils:
 - a. Cooling Condensate Drain Pan and Drain Connection:
 - 1) Fabricate from stainless 20 gauge, 0.0359 inch (0.91 mm) sheet steel, extend 3 inches (75 mm) from face of entering air side, 6 inches (150 mm) from the face of the leaving air side, and 4 inches (100 mm) from the face of moisture eliminators.
 - 2) Design slope in accordance with ASHRAE Std 62.1 and install to prevent standing water.
 - 3) Pipe drains individually to floor drain with water seal trap.
 - b. Install condensate drain pan under each main cooling coil and intermediate condensate drain pan at each level of stacked cooling coils to collect all condensate from coil assembly, pipe header, pipe return bends, upstream run-off, and downstream carry-over.
 - c. Insulate bottom of intermediate drain pans for coils mounted in 100 percent outdoor air units with 3/8 inch (10 mm) thick flexible closed cell elastomeric insulation, with the upstream edge protected by stainless steel angle.
 - 1) Provide rigidly supported, leak-tight copper drain piping from each intermediate pan to pan below.

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- 2) Flexible Closed Cell Elastomeric Drain Pan Insulation: See Section 230716 and Section 230719.

3.3 FIELD QUALITY CONTROL

- A Provide manufacturer's field representative to test, inspect, instruct, and observe.

3.4 CLEANING

- A After construction and painting is completed, clean exposed surfaces of units.
- B Vacuum clean coils and inside of units.
- C Touch-up marred or scratched surfaces of factory-finished cabinets using finish materials furnished by the manufacturer.
- D Install new filters.

END OF SECTION 238200

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SECTION 238413.29
SELF-CONTAINED HUMIDIFIERS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Gas-fired humidifiers.

1.2 RELATED REQUIREMENTS

- A Section 230719 - HVAC Piping and Equipment Insulation.

1.3 REFERENCE STANDARDS

- A AHRI 640 (I-P) - Performance Rating of Commercial and Industrial Humidifiers; 2017.
- B ASME B31.9 - Building Services Piping; 2020.
- C ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2022.
- D ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2020.

1.4 SUBMITTALS

- A See Section 013000 - Administrative Requirements, for submittal procedures.
- B Product Data: Provide catalog sheets indicating general assembly, dimensions, weights, materials, and certified performance ratings.
- C Shop Drawings: Indicate general assembly, dimensions, weights, and materials.
- D Field Quality Control Submittals:
 - 1. Unit nameplate data and actual voltage and ampere consumption.
 - 2. Load-side supply and return water flow and temperatures and measurement equipment.
 - 3. Source-side supply and return water flow and temperatures and measurement equipment.
 - 4. Date, name, and signature of person testing and reporting.
- E Executed warranty.

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1.5 WARRANTY

- A Manufacturer's Warranty: Provide minimum two-year warranty to include coverage for materials and labor for complete assembly. Complete forms in Owner's name and register with manufacturer.

PART 2 PRODUCTS

2.1 GAS-FIRED HUMIDIFIERS

- A Manufacturers:
1. Neptronic
 2. Condair
- B Description: Humidifiers providing sterile steam humidification by using gas-fired burners to generate heat. Heat is transferred to water using immersed heat exchanger. Water heated to steam at atmospheric pressure.
1. Comply with AHRI 640 (I-P).
- C Steam Delivery:
1. Location of Steam Termination: As indicated on drawings.
 2. Dispersion Method: Steam dispersion tubes.
- D Cabinet: Protective steel or aluminum housing cabinet for floor-mounted, indoor installation.
- E Water Tank: Thermally insulated stainless steel vessel; holds and stores water during heating process. Tank is removable.
1. Sensors: Includes sensors for aquastat, overheat protection, water foam detection, water conductivity detection, and water level. Sensors compatible with and resistant to corrosion from incoming water type.
- F Gas-Fired Heating System: Gas-fired combustion burner transfers heat to heat exchanger submerged in water inside heating tank. To facilitate rapid-response steam production, heater maintains water at warm temperature during active periods when steam is not presently called for.
1. Fuel: Use natural gas.
 2. Temperature Maximum: Heat water to 212 degrees F (100 degrees C) steam.
 3. Combustion System: Use variable speed forced draft combustion chamber constructed of stainless steel with negative pressure gas regulating valve.
 4. Heat Exchanger: Constructed of stainless steel; removable and cleanable.
- G Scale Mitigation: Humidifier automatically controls and mitigates scale buildup.

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- H Overfill Protection: Humidifier automatically prevents water overflow.
- I Drain Water: Water tank periodically drained according to conductivity sensor or timer to maintain purity.
1. Humidifier partially drains and refills tank during active use.
 2. Humidifier fully flushes water tank at set intervals.
 3. Filter: Captures scale prior to emptying wastewater into plumbing.
 4. Water Tempering: Water discharged from humidifier is temperature of 140 degrees F (60 degrees C) or less.
 - a. Drain valve opens once heating elements have turned off, and temperature sensor in tank detects water has reached acceptable drain temperature.
- J Incoming Water:
1. Water Type: Reverse osmosis demineralized.
- K Incoming Water Connection:
1. Connection Type: Type L copper piping.
 - a. Copper Tubing: Comply with ASTM B88/ASTM B88M.
 2. Size: Sized according to manufacturer's instructions.
- L Control System:
1. Provide microprocessor-based control system for automatic control, and monitoring. Include sensors, wiring, and connections necessary for functions and status/alarm indications specified.
 2. Provide digital display interface with touchscreen or button controls for automatic/manual programming and display of status, logs, and alarms.
 3. Integrate with building automation system.
 - a. Scheduling: Seven-day week clock and scheduler.
 4. Network Communications Support: Modbus and BACnet.
 5. Modes: Manual, automatic modulate, and off.
 6. Solenoid Fill Valve: Opens to maintain water level. Close when water level is satisfied and during periods of flushing.
 7. Gas cock and safety gas shutoff valve upstream of humidifier connection.
 8. Gas Valve: Open upon call for heat.
 9. Flame Detection: Confirms flame during combustion.
 10. Gas train is shut down upon detection of failure or unsafe conditions.
 11. Periodically partially drain and refill water upon call to maintain tank water purity.
 12. On-demand manual water drain.
 13. Drain Valve: Open upon call to drain water. Open upon power loss.
 14. Modulate humidification output to satisfy demand.
 15. Provide Sensors:
 - a. Room humidity sensor with acceptable upper and lower limits.
 - b. Water treatment sensor.
 - c. Water conductivity sensor.
 - d. Aquastat.

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- e. Water level sensor.
- f. Flame detection sensor.
- 16. Alarms: Alarm activates upon the following events. Controller may be programmed for shutdown by one or more of the following:
 - a. Sensor failure.
 - b. Sensor detects high or low setpoint reached.
 - c. DDC signal failure.
 - d. Drain failure.
- 17. Emergency shut-off.
- 18. System Status Log: Minimum 30-day history log.
 - a. Run time.
 - b. Current alarms.
 - c. Alarm history.
 - d. Sensor reading.
 - e. Zone humidity setpoint.
 - f. Time of next cleaning and maintenance.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine equipment bases, locations, connection sizes, and conditions affecting performance, maintenance, and operations.
- B Verify that field measurements are as indicated.
- C Verify exact piping connection locations.
- D Verify sufficient space for pipe routing.
- E Verify that rough-ins for field connections are in proper locations.
- F Verify clearances will be satisfied after installation is complete.
- G Verify that electric power is available and of correct characteristics.
- H Proceed with installation after correction of unsatisfactory conditions.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions.

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- B Unit Mounting:
 - 1. Do not obstruct maintenance access to equipment by ductwork, piping, electrical conduit, or other utility.
- C Install control wiring.
- D Connect unit to water supply. Provide isolation valve on water supply line.
- E Adjust waterflow.
- F Pipe drain and overflow connections to nearest floor drain.

3.3 FIELD QUALITY CONTROL

- A Perform tests and inspections. Prepare reports.
 - 1. Installation and startup checks.
 - 2. Hydrostatic test. Repair leaks and retest until no leaks exist in accordance with ASME B31.9.
 - 3. Test and adjust controls and safeties.
 - 4. Check and adjust operating and safety setpoints of water level.
- B Upon completion and before final acceptance of work, test each system to demonstrate compliance with Contract Documents.
 - 1. Adjust controls and balance systems prior to final acceptance of completed systems.
 - 2. Test controls through every cycle of operation.
 - 3. Test safety controls to demonstrate performance of required function.
 - 4. Furnish water, electricity, instruments, connecting devices, and personnel for tests.
 - 5. Clean equipment, piping, strainers, ducts, and filters.
 - 6. Correct defects in work and repeat tests.
- C Operational Testing: After demonstration of satisfactory operation perform operational testing:
 - 1. Test each item of equipment in operation for continuous period of minimum of 24 hours under every condition of operation in accordance with equipment manufacturer's recommendations.
 - 2. Verify that each item of equipment operating parameters are within limits recommended by manufacturer.
 - 3. Manufacturer's Recommended Test: Conduct manufacturer's recommended field testing; provide factory-trained field representative authorized by and to represent equipment manufacturer during complete execution of field testing.

3.4 CLEANING

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- A Clean dirt and debris from controller enclosures and components in accordance with manufacturer's instructions.
- B Clean exposed surfaces, media pad, headers, distribution bars to remove dirt, paint, or other foreign material and restore to match original factory finish.
- C Install new air filters.
- D Install new water filters.

3.5 CLOSEOUT ACTIVITIES

- A Demonstration: Demonstrate proper operation of controllers to Owner, and correct deficiencies or make adjustments as directed.
- B 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. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.

3.6 MAINTENANCE

- A Provide maintenance contract to Owner for service and maintenance of humidifier for two years from Date of Substantial Completion; Include complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with detailed schedule.
- B Provide trouble call-back service upon notification by Owner:
 - 1. Provide on-site response within 1 business day of notification.

END OF SECTION 238413.29

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SECTION 260100
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A It is intended this facility obtain a minimum LEED 4.0 rating. LEED criteria will be followed for the installation of building systems. This Contractor shall be responsible for the following items to ensure the Facility achieves LEED certification:
1. LT credits
 - a. Green Vehicles
 2. SS credits
 - a. Light Pollution Reduction.
 3. EA prerequisites
 - a. Fundamental Commissioning and Verification
 - b. Minimum Energy Performance
 - c. Building-Level Energy Metering
 4. EA credits
 - a. Enhanced Commissioning
 - b. Optimize Energy Performance
 - c. Advanced Energy Metering
 - d. Demand Response
 - e. Renewable Energy Production
 - f. Green Power and Carbon Offsets
 5. MR prerequisites
 - a. Construction and Demolition Waste Management Planning
 - b. PBT Source Reduction - Mercury
 6. MR credits
 - a. PBT Source Reduction - Mercury
 - b. Construction and Demolition Waste Management
 7. IEQ credits
 - a. Low Emitting Materials: Adhesives and Sealants
 - b. Low Emitting Materials: Paints and Coatings
 - c. Interior Lighting
 - d. Daylight

1.3 REFERENCE STANDARDS

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- A NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.

1.4 DELIVERY, STORAGE, AND HANDLING

- A Conduit, conductors, boxes, electrical equipment, and associated accessories kept on-site are to be stored off the ground on skids, ends are to be capped or sealed, and these items should be covered with plastic to prevent fouling or contact with excessive moisture. Conduit, conductors, boxes, electrical equipment are to be cleaned of debris inside and out before installation and are to be kept clean and protected throughout construction.
- B Store plastic raceways protected from direct sunlight. Support to prevent sagging and bending.

1.5 COORDINATION

- A Arrange for conduit routing spaces, chases, slots, and openings in building structure during progress of construction, to allow for electrical 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 electrical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08.
- D Install additional distribution offsets as required to obtain maximum headroom or to avoid conflicts with other work, without additional cost to the Owner.
- E The Contractor shall produce full coordination drawings between all trades identifying any areas of interference or clashes prior to the start of construction. Modifications shall be made to the associated systems to resolve the issue in coordination with and approval of the Architect and Engineer.
- F It is required that Contractor visits the site of the work and become familiar with the conditions affecting the installation prior to bidding. Submission of a Bid shall presuppose knowledge of such conditions and no additional compensation shall be allowed where extra labor or materials are required because of the lack of knowledge of these conditions.

1.6 DESIGN DRAWINGS

- A The Contract Drawings are diagrammatic and are not intended to show exact location of conduit, conductors, boxes, electrical equipment unless dimensions are given. Systems and distribution are to be installed along the general plans shown on the Drawings, but in coordination with actual field conditions.

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- B Extra costs which might result from deviations from the Drawings, so as to avoid interferences, shall be considered a "Job Condition", and no additional compensation will be considered applicable. In the event that such interferences occur in the course of the Work, due to an error, omission, or oversight by the Contractor, no additional compensation shall be allowed. Interferences which may occur during the course of construction shall be brought to the immediate attention of the Architect, and his/her decision, confirmed in writing, shall be final.

PART 3 EXECUTION

2.1 INSTALLATION - COMMON REQUIREMENTS

- A Comply with any applicable Owner Required Design Standards.
- B Comply with NECA, NFPA, and OSHA requirements.
- C All work shall be installed in a neat, workmanlike manner in accordance with NECA 1.
- D All materials and equipment provided under this contract shall be new (except where otherwise noted) and shall be listed, labeled or certified by Underwriters Laboratories, Inc.
- E All equipment of the same type and capacity shall be by the same manufacturer.
- F Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.
- G During construction the contractor shall at all times maintain electrical utilities of the building without interruption. Should it be necessary to interrupt any electrical service or utility, the contractor shall secure permission in writing from the Owner for such interruption at least seven days in advance. Any interruption shall be made with minimum amount of inconvenience to the Owner and any shut-down time shall have to be on a premium time basis and such time to be included in the contractor's bid. Arrange to provide and pay for temporary power source if required by project conditions.
- H Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounted items.
- I Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

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- J Working clearance around equipment shall not be less than that specified in the N.E.C. for all voltages specified.
- K The locations of switches, receptacles, lights, motors, etc. outlets shown are approximate. The contractor shall use good judgment in placing the preceding items to eliminate all interference with ducts, piping, etc. The contractor shall check all door swings so that light switches are not located behind doors. Relocate switches as required, with approval from the Design Professional. Owner may direct relocation of outlets before installation, up to five (5) feet from the position indicated on the Drawings, without additional cost.
- L Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity. Normal maintenance shall not require the removal of protective guards from adjacent equipment. Install equipment as close as practical to the locations shown on the Drawings.
1. Where the Owner determines that the Contractor has installed equipment not conveniently accessible for operations and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Owner.
 2. "Conveniently Accessible" is defined as being capable of being reached without use of ladders, or without climbing or crawling over or under obstacles such as motors, pumps, belt guards, transformers, racks, piping, ductwork, raceways or similar.
- M Right of Way: Give to piping systems installed at a required slope. Coordinate with Division 22 and 23 prior to rough-in.
- N Firestopping shall be applied to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of the assembly according to Division 07 and 09 Sections.
- O Owner furnished equipment: Equipment furnished by the Owner shall be received, stored, uncrated, protected, and installed by the Contractor with all appurtenances required to place the equipment in operation, ready for use. The Contractor shall be responsible for the equipment as if he had purchased the equipment himself.

END OF SECTION 260100

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SECTION 260101
ELECTRICAL DEMOLITION

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
 - 1. Demolition and removal of selected portions of electrical items.
 - 2. Salvage of existing items to be reused or recycled.

1.3 DEFINITIONS

- A Remove: Detach items from existing construction and legally dispose of them off-site, unless indicated to be removed and salvaged or removed and reinstalled.
- B Remove and Reinstall: Detach items from existing construction, prepare them for reuse, and reinstall them where indicated. Extend wiring and conduit as required.
- C Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 MATERIALS OWNERSHIP

- 1. Coordinate with contracting officer, who will establish special procedures for removal and salvage.

1.5 QUALITY ASSURANCE

- A Demolition Firm Qualifications: An experienced firm that has specialized in demolition work similar in material and extent to that indicated for this Project.
- B Regulatory Requirements: Comply with governing EPA notification regulations before beginning electrical demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- C Standards: Comply with ANSI A10.6 and NFPA 241.

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- D Predemolition Conference: Conduct conference at Project site to comply with:
1. Inspect and discuss condition of construction to be selectively demolished.
 2. Review structural load limitations of existing structure.
 3. Review and finalize electrical demolition schedule and verify availability of materials, demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 4. Review requirements of work performed by other trades that rely on substrates exposed by selective demolition operations.
 5. Review areas where existing construction is to remain and requires protection.

1.6 PROJECT CONDITIONS

- A Owner will occupy portions of building immediately adjacent to electrical demolition area. Conduct electrical demolition so Owner's operations will not be disrupted.
- B Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
- C Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
1. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify contracting officer. Contracting officer will have hazardous materials removed under a separate contract.
- D Storage or sale of removed items or materials on-site is not permitted.
- E Utility Service: Maintain existing utilities indicated to remain in service and protect them against damage during demolition operations.
1. Maintain fire-protection facilities in service during demolition operations.

1.7 WARRANTY

- A Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during demolition, by methods and with materials so as not to void existing warranties.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 EXAMINATION

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- A Survey existing conditions and correlate with requirements indicated to determine extent of demolition required.
- B Inventory and record the condition of items to be removed and reinstalled and items to be removed and salvaged.
- C When unanticipated electrical elements that conflict with intended function or design are encountered, investigate and measure the nature and extent of conflict. Promptly submit a written report to Contracting Officer. Contractor is responsible for all items, demolition and reinstallation whether shown on the drawings or not shown on the drawings.

3.2 UTILITY SERVICES AND ELECTRICAL SYSTEMS

- A Existing Electrical Services/Systems: Maintain electrical services/systems indicated to remain and protect them against damage during selective demolition operations.

3.3 ELECTRICAL DEMOLITION, GENERAL

- A Removed and Reinstalled Items:
 - 1. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.
 - 2. Pack or crate items after cleaning and repairing. Identify contents of containers.
 - 3. Protect items from damage during transport and storage.
 - 4. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

3.4 DISPOSAL OF DEMOLISHED MATERIALS

- A General: Except for items or materials indicated to be reused, salvaged, reinstalled, or otherwise indicated to remain Owner's property, remove demolished materials from Project site and legally dispose of them in an EPA-approved landfill.
 - 1. Do not allow demolished materials to accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B Burning: Do not burn demolished materials.
- C Disposal: Transport demolished materials off Owner's property and legally dispose of them.

3.5 CLEANING

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- A Clean adjacent structures and improvements of dust, dirt, and debris caused by electrical demolition operations. Return adjacent areas to condition existing before electrical demolition operations began.

END OF SECTION 260101

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SECTION 260513
MEDIUM-VOLTAGE CABLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes medium voltage shielded power cables, sizes 1/0 through 2000 kcmil, related splices, terminations, and accessories for medium-voltage electrical distribution systems, 5 kV through 35 kV.

1.3 DEFINITIONS

- A NETA ATS: National Electrical Testing Association Acceptance Testing Specification.

1.4 ACTION SUBMITTALS

- A Product Data: For each size and type of cable indicated.
- B Include data sheets for the following additional items:
 - 1. Splices and terminations.
 - 2. Separable connectors.
 - 3. Cable accessories.

1.5 INFORMATIONAL SUBMITTALS

- A Field quality-control test reports.

1.6 QUALITY ASSURANCE

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- A Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable. Cable splicer shall have a minimum of 2000 hours experience with terminating and installing medium voltage cable. Furnish satisfactory proof of such experience for each employee who splices or terminates the cables. Persons listed by the Contractor may be required to perform a dummy or practice splice and termination in the presence of the Owners representative or Engineer before being approved as a qualified installer of medium-voltage cables.
- B Source Limitations: Obtain cables and accessories through one source from a single manufacturer.
- C Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D Comply with IEEE C2 and NFPA 70.
- E Comply with ASTM B3 and B8.
- F Comply with UL requirements.
- G Comply with Owner Design Standards.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cables:
 - a. Pirelli.
 - b. Okonite Company (The).
 - c. Rome.
 - 2. Cable Splicing and Terminating Products and Accessories:
 - a. Raychem Corp.; Tyco International Ltd.
 - b. PLM.
 - c. 3M; Electrical Products Division.

2.2 CABLES

- A Cable Type: Single conductor, UL type MV105 approved for N.E.C. applications.

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- B Comply with UL 1072, AEIC CS 8, ICEA S-93-639/NEMA WC74, and ICEA S-97-682.
- C Conductor: Annealed, soft drawn Copper.
- D Conductor Stranding: Compact round, concentric lay, Class B.
- E Conductor Insulation: discharge free, no lead, Ethylene-Propylene Rubber (EPR), color contrasted with strand and insulation shields.
 - 1. Voltage Rating: 15 kV.
 - 2. Insulation Thickness: 133 percent insulation level.
- F Strand Shielding: Black extruded semi-conducting thermoset copolymer applied directly over the conductor.
- G Insulation Shield: Black extruded semiconducting thermoset copolymer applied directly over the insulation.
- H Shielding: Copper tape, 5 mils thick, helically applied with 25% overlap, over semiconducting insulation shield or six solid copper corrugated drain wires embedded longitudinally in composite layers of semi conducting thermoset copolymer and CPE.
- I Cable Armor: Aluminum Interlocked Armor (AIA) applied over cable with overall PVC jacket
 - 1. Listings: cables shall be UL listed "For CT Use".
 - 2. Jacket shall be color coded for voltage identification.
- J Cable Jacket: Chlorinated Polyethylene, CPE per ICEA and UL 1072.
- K Identification: The following minimum legend shall be printed on the jacket and repeated at not more than two foot intervals.
 - 1. Manufacturer/plant no.
 - 2. Conductor size (awg or kcmil).
 - 3. CU.
 - 4. EPR.
 - 5. SHLD.
 - 6. Voltage (kV).
 - 7. Insulation level (133%).
 - 8. Insulation thickness (mils), MV-105.

2.3 SPLICE KITS

- A Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

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- B Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
1. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
 2. Pre-molded, cold-shrink-rubber, in-line splicing kit.

2.4 SOLID TERMINATIONS

- A Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
 2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer non-tracking tubes; multiple, molded, non-tracking skirt modules; and compression-type connector.
 3. Class 2 Terminations, Indoors: Kit with stress-relief tube, non-tracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
 4. Medium voltage cable terminations and splices: long barrel, 2-hole hydraulic crimp lugs.

2.5 SEPARABLE INSULATED CONNECTORS

- A Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- D Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

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- E Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
 2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
- F Tool Set: Shotgun hot stick with energized terminal indicator, and carrying case.
- G Ground Bails: Heavy duty grounding bails shall be provided to accommodate portable grounding equipment.

2.6 ARC-PROOFING MATERIALS

- A Tape for First Course on Metal Objects: Scotch 88, 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- B Arc-Proofing Tape: Scotch 77, fireproof tape, flexible, conformable, and intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.
- C Self-fusing Silicon Tape: Scotch 70, high temperature, arc and track resistant tape composed of self-fusing, inorganic silicone rubber.
- D Glass-Cloth Tape: Scotch 69, Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

2.7 SOURCE QUALITY CONTROL

- A Test and inspect cables according to ICEA S-97-682 before shipping.
- B Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 EXECUTION

3.1 INSTALLATION

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- A Minimum cable size shall be #1/0 awg.
- B Install cables according to IEEE 576.
- C Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values for single or multi-conductor cables.
 - 1. A strand dynamometer/tension meter shall be used during the cable installation, readings shall be recorded and a report submitted for each cable pull.
 - 2. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
 - 3. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
 - 4. Provide cable lengths with liberal allowances of slack for terminations.
 - 5. Cable ends shall be moisture proofed at all times until terminations are installed.
- D Install exposed cables in tunnels in suitable cable trays, cables shall be secured with UL listed tie wrap materials.
- E Install underground cables in Sch. 40 PVC conduits in concrete encased ductbanks, comply with Section 260543.
- F In buildings and at road crossings, install cables in Rigid Galvanized Conduit (Heavy-wall).
- G Provide an insulated, stranded copper ground conductor in each conduit with phase conductors.
- H Medium voltage cables shall not be direct buried.
- I Install permanent markers at ends of cable runs, changes in direction, and splices.
- J Install "buried-cable" detectable, warning tape above ductbanks. Comply with Sections 260543 and 260553.
- K Outdoor splices and terminations shall be performed in dry conditions only.
- L In manholes, hand holes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables with suitable UL listed non-metallic racks, located at intervals adequate to prevent sag.

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- M Pull all cables in continuous lengths, splices shall be avoided unless necessitated by the length of the run. Locations of all splices shall be approved by the Owner Facilities Engineering representative in writing.
- N Install separable insulated-connector components as follows:
1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 2. Portable Feed-Through Accessory: Three.
 3. Standoff Insulator: Three.
- O Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, or termination materials such as transformers, switchgear, and manholes. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
1. Clean cable sheath.
 2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
 3. Smooth surface contours with electrical insulation putty.
 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 5. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) O.C.
- P Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Sections and Owner Fire Protection Group.
1. All penetrations shall be under constant visual surveillance until firestopping is applied.
 2. Products: Cooper B –Line, 3M, Hilti, Specified Technologies, Inc.
- Q Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- R Identify cables according to Division 26 Section 260553 "Identification for Electrical Systems."
1. Identify individual phases at termination points.
 2. In manholes, cables shall be identified where cables enter and leave the manhole. Identify circuit number and voltage.
 3. Use embossed brass tags tie wrapped to cable.

3.2 FIELD QUALITY CONTROL

- A Perform the following field tests and inspections and prepare test reports:
1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.

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2. After installing medium-voltage cables and terminations but before electrical circuitry has been connected to busses or switchgear and energized, test for compliance with requirements, including but not limited to DC high potential testing according to IEEE 400 and insulation resistance testing.
- B Remove and replace non-compliant cable or terminations and retest as specified above.

END OF SECTION 260513

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SECTION 260519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. VFD Cabling
 - 4. Metal clad cable
 - 5. Mineral-insulated cable, Type MI, rated 600 V or less.
- B Related Sections include the following:
 - 1. Division 27 Sections for cabling used for voice and data circuits.

1.3 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.
- B Comply with ASTM.
- C Comply with UL 44, 83, and 486.
- D Comply with NFPA 70.
- E Comply with NFPA 99.
- F Comply with Owner Specific Design Standards

1.4 SUBMITTALS

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- A Product Data: For each type of product indicated.
- B Include data sheets for the following additional items:
 - 1. Splices and terminations.
 - 2. Pulling compounds.
 - 3. Cable accessories.
- C Field quality-control test reports.

1.5 PROJECT CONDITIONS

- A Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Owner's permission.
 - 3. Owner's Lock-out/Tag-out procedures shall be used with Contractor controlled locks and tags.
 - 4. Comply with NFPA 70E.

PART 2 PRODUCTS

2.1 CONDUCTORS AND CABLES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Copper Conductors
 - a. Okonite
 - b. Southwire Company
 - c. Traingle
 - d. Rome
 - e. Cablec
- B Conductors
 - 1. Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- C Conductor Insulation:
 - 1. Comply with NEMA WC 70 for Types THHN-THWN, XHHW-2 and SO.
 - 2. Voltage rating: 600 Volts for 480/277V and 208/120V.

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D VFD Cable

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AmerCable Inc.
 - b. Belden Inc.
2. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
3. Type TC-ER with oversized cross-linked polyethylene insulation, dual spirally wrapped copper tape shields and three bare symmetrically applied ground wires, and sunlight- and oil-resistant outer PVC jacket.
4. Comply with UL requirements for cables in Class 1, Division 2 hazardous location applications.

E Metal Clad Cable

1. Manufacturers:
 - a. AFC Cable Systems Inc: www.afcweb.com.
 - b. Encore Wire Corporation: www.encorewire.com.
 - c. Service Wire Co: www.servicewire.com.
 - d. Southwire Company: www.southwire.com.

F 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.

G Conductor Stranding:

1. Size 10 AWG and Smaller: Solid.
2. Size 8 AWG and Larger: Stranded.

H Insulation Voltage Rating: 600 V.

I Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.

J Provide oversized neutral conductors.

K Provide dedicated neutral conductor for each phase conductor.

L Grounding: Full-size integral equipment grounding conductor.

1. Provide additional isolated/insulated grounding conductor.

M Armor: Steel, interlocked tape.

N Provide PVC jacket applied over cable armor

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- O 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: 10 ft
 - 2. In addition to other applicable restrictions, may not be used:
 - a. Unless approved by Owner.
 - b. Where not approved for use by the authority having jurisdiction.
 - c. Where exposed to view.
 - d. Where exposed to damage.
 - e. For damp, wet, or corrosive locations.
 - f. For isolated ground circuits.

2.2 CONNECTORS AND SPLICES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Burndy, Thomas & Betts.
 - 2. O-Z/Gedney; EGS Electrical Group LLC.
 - 3. 3M; Electrical Products Division.
 - 4. IlSCO.
 - 5. GB Electric
- B Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
 - 1. Aboveground Circuits (No. 10 AWG and smaller):
 - a. Connectors: Solderless, screw-on, reusable pressure cable type, rated 600 V, 90° C, with integral insulation, approved for copper conductors.
 - b. The integral insulator shall have a skirt to completely cover the stripped wires.
 - c. The number, size, and combination of conductors, as listed on the manufacturer's packaging, shall be strictly followed.
 - 2. Aboveground Circuits (No. 8 AWG and larger):
 - a. Cable termination lugs shall be made of high conductivity and corrosion-resistant material, electro-tin plated, listed for use with copper conductors only, rated for 600 V. Lugs shall be color coded by size.
 - b. Cable termination lugs shall be indent type, long barrel with chamfered entry, 2 – hole, compression type for 250 kcmil and above, 1 – hole for less than 250 kcmil.

2.3 MINERAL-INSULATED CABLE, TYPE MI, FOR FIRE PUMP FEEDERS

- A Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.

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B Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. KME America, Inc.
2. Pentair.
3. Watlow Electric.

C Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. UL 2196 for fire resistance.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D Conductors: Copper, complying with ASTM B3 for bare annealed copper.

E Insulation: Compressed magnesium oxide.

F Sheath: Copper.

PART 3 EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A Feeders:

1. Copper for feeders equal to or smaller than No. 2 AWG.
2. Copper for feeders larger than No. 2 AWG.
3. All feeders shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B Branch Circuits:

1. Copper.
2. All branch circuits shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

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- C Minimum Wire Size: #12 awg for power and lighting circuits, #14 awg for control circuits. For 277-volt branch circuits, in the case of "homeruns" over 125 feet in length, no conductor smaller than a #10 awg wire shall be used. For 120-volt branch circuits, in the case of "homeruns" over 75 feet in length, no conductor smaller than a #10 awg wire shall be used; in the case of "homeruns" over 150 feet in length, no conductor smaller than a #8 awg wire shall be used. In all cases, the tap conductor from the J-box in the ceiling to the device may be #12 awg. Each 277-volt or 120-volt phase conductor shall have a neutral conductor of the same size. The sizing of all wire except remote control wire shall be accomplished in the case of both feeder and branch circuits by conforming to the following provisions. Lighting and receptacle circuits may share grounding conductors. All lighting and receptacle circuits with shared grounding conductors shall be #10 awg minimum.

3.2 CONDUCTOR INSULATION AND MULTI-CONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A Service Entrance: Type XHHW, or type THHN/THWN up to and including 600 kcmil.
- B Exposed Feeders: Type XHHW for #2 awg and larger, or type THHN/THWN for all sizes up to and including 600 kcmil, single conductors in raceway.
- C Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type XHHW for #2 awg and larger, or type THHN/THWN for all sizes up to and including 600 kcmil, single conductors in raceway.
- D Feeders Concealed in Concrete, below Slabs-on-Grade, and underground: Type XHHW for #2 awg and larger, or type THHN/THWN for all sizes up to and including 600 kcmil, single conductors in raceway.
- E Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- F Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- G VFD Output Circuits: Type TC-ER cable with dual tape shield.
- H Branch Circuits Concealed in Ceilings, Walls, and Partitions for Isolated Power Panel (IPP) Systems in Operating Rooms, ICU or CCU: Type XHHW or XHHW-2, low leakage, with a dielectric constant of 3.5 or less, single conductors in raceway.
- I Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.

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- J Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, and strain relief device at terminations to suit application.
- K Recessed or Semi-recessed Lighting Fixture Whips: Type THHN-THWN (90 deg C), single conductors in FMC in lengths not to exceed six (6) feet , or HCF Armored Cable on normal circuits, or in non-patient care areas.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A Splices in feeder circuits shall be avoided unless necessitated by the length of the run. Locations of all splices shall be approved by the Owner.
- B Phase Conductors may be run parallel from sizes 250 kcmil up to and including 750 kcmil provided all paralleled conductors are of the same size, manufacturer, length and type of insulation. Minimum parallel ground conductors to be #1/0.
- C Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- E Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- F Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems" for secondary service, feeders and branch circuits.

3.4 CONNECTIONS

- A Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.
- B Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack in accordance with NEC 300.14.

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3.5 FIRESTOPPING

- A Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Sections.
 - 1. All penetrations shall be under constant visual surveillance until firestopping is applied.
 - 2. Products: Cooper B –Line, 3m, Hilti, Specified Technologies, Inc.

3.6 FIELD QUALITY CONTROL

- A Perform tests and inspections and prepare test reports.
- B Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - a. Generator, UPS, Isolated Power Panel, Fire Pump.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D Remove and replace non-compliant cables or wires and retest as specified above.

END OF SECTION 260519

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SECTION 260526
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes: Grounding systems and equipment.
- B Section includes grounding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.

1.3 ACTION SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NFPA 70B.
 - a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 - b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B Comply with UL 467 for grounding and bonding materials and equipment.

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C Comply with NFPA 70.

D Comply with NFPA 99.

PART 2 PRODUCTS

2.1 CONDUCTORS

- A Insulated Conductors: Tinned-copper wire or cable insulated for 600 V with green colored insulation, UL 44 or UL 83 listed, unless otherwise required by applicable Code or authorities having jurisdiction.
- B Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, provided with standard NEMA bolt hole sizing and spacing for the type of connectors to be used. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V, Lexan or PVC, impulse tested at 5000 V. Provide clear Lexan cover over connections.

2.2 CONNECTORS

- A Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
1. Pipe Connectors: Clamp type, sized for pipe.
- C Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

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- D Bus-bar Connectors: Mechanical type, cast silicon bronze, solder-less compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

- A Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 EXECUTION

3.1 APPLICATIONS

- A Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank as part of duct-bank installation. Bury detectable warning tape approximately 6 inches (150 mm) above grounding conductors. Warning tape shall comply with Section 260553.
- C Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D Grounding Bus: Install in electrical rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.
- E Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Exothermic welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Exothermic welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A Comply with IEEE C2 grounding requirements.

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- B Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, non-shrink grout.
- C Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2/0 for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 12 inches (300 mm) from the foundation.

3.3 UTILITY GROUNDING

- A Provide grounding and bonding at Utility Company's metering equipment in accordance with Utility Company's requirements.

3.4 EQUIPMENT GROUNDING

- A Install insulated equipment grounding conductors with all feeders and branch circuits.
 - 1. Conduit shall not be used as the ground conductor.
- B Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Lighting circuits.
 - 3. Receptacle circuits.
 - 4. Single-phase motor and appliance branch circuits.
 - 5. Three-phase motor and appliance branch circuits.
 - 6. Flexible raceway runs.
 - 7. Armored cable runs.
 - 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.

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9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- C Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- F Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- G Cable trays shall be grounded and bonded in accordance with N.E.C. requirements.
- H Raised floors: Provide bonding of all raised floor components.
- I Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- J Outdoor metallic fences around electrical equipment shall be grounded.

3.5 INSTALLATION

- A Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
1. 1. Where ground conductors are subject to physical damage, install in raceway.

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- B Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C Ground Rods: Drive rods until tops are 12 inches (100 mm) below finished floor or final grade unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- D Test Wells: Ground rod driven through bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
1. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
 4. Bond each portion of the medical gas piping system downstream from equipment shutoff valve.
- G Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

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- H Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
- I Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
 - 1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
 - 2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.
- J Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
 - 1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
 - 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
 - 3. UFER ground electrode shall be properly supported to insure proper placement while concrete is being poured, the conductor shall be supported every 30" or less and be properly tensioned to prevent sag.

3.6 LABELING

- A Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.

3.7 FIELD QUALITY CONTROL

- A Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

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- a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C Grounding system will be considered defective if it does not pass tests and inspections.
- D Prepare test and inspection reports, submit to Engineer.
- E Report measured ground resistances that exceed the following values:
- 1. Power and Lighting Equipment or System with Capacity of 500 kVA and less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
 - 5. Substations and Pad-Mounted Equipment: 5 ohms.
 - 6. Manhole Grounds: 10 ohms.
- F Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

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SECTION 260529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B Related Sections include the following:
 - 1. WHERE REQUIRED BY PROJECT CONDITIONS

1.3 DEFINITIONS

- A EMT: Electrical metallic tubing.
- B IMC: Intermediate metal conduit.
- C RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 QUALITY ASSURANCE

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- A Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B All products shall be UL labeled for their intended use.
- C Comply with NFPA 70.

1.6 COORDINATION

- A Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Sections.

PART 2 PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.

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2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
 4. Rated Strength: Selected to suit applicable load criteria.
- C Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- D Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- E Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- F Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- G Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

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- 6. Toggle Bolts: All-steel springhead type.
- 7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B Materials: Comply with requirements in Division 05 Sections for steel shapes and plates.

PART 3 EXECUTION

3.1 APPLICATION

- A Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with single-bolt conduit clamps or single-bolt conduit clamps using spring friction action for retention in support channel.
- D Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- E Fire pump feeders that are run exposed shall have conduit supported every five feet from a two hour rated structure with UL listed components.

3.2 SUPPORT INSTALLATION

- A Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

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- C Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A Comply with installation requirements in Division 05 Sections for site-fabricated metal supports.
- B Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit and four inches high, and so anchors will be a minimum of 10 bolt diameters from edge of the base. Edges shall be chamfered.
- B Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Concrete Sections.

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- C Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
- D Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B Touchup: Comply with requirements in Division 09 Painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A-780.

END OF SECTION 260529

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SECTION 260533
RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B Owners IT/IS Standards for raceways and cable trays for Telecommunications cabling.

1.2 SUMMARY

- A Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetallic conduits, tubing, and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Nonmetallic wireways and auxiliary gutters.
 - 5. Surface raceways.
 - 6. Poke Thru Assemblies.
 - 7. Medical grade Trench Duct.
 - 8. Boxes, floor boxes, enclosures, and cabinets.
- B Related Requirements:
 - 1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
 - 2. Owners IT/IS Standards for pathways for Electronic Safety, Communications and Security Systems.

1.3 DEFINITIONS

- A ARC: Aluminum rigid conduit.
- B GRC: Galvanized rigid steel conduit.
- C IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

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- A Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B LEED Submittals:
 - 1. Product Data for IEQ Credit: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for IEQ Credit: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.5 QUALITY ASSURANCE

- A All products shall be UL labeled for their intended use.
- B Comply with NFPA 70.
- C Comply with NFPA 99.
- D Comply with Owner Design Standards.

PART 2 PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A Manufacturers: Subject to compliance with requirements, products of all manufacturers are acceptable provided they have a smooth interior, are UL listed and labeled as defined in NFPA 70 for the intended location and application, and are electro-galvanized steel (EMT) or hot dipped galvanized steel inside and out (GRC). Conduit and fittings shall be obtained from the same manufacturer:
- B Aluminum EMT is permitted in lieu of electro-galvanized steel EMT for trade sizes 1-1/2" and larger, unless not permitted elsewhere in these specifications.
- C GRC: Comply with ANSI C80.1 and UL 6.
- D ARC: Comply with ANSI C80.5 and UL 6A.
- E IMC: Comply with ANSI C80.6 and UL 1242.

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- F EMT: Comply with ANSI C80.3 and UL 797.
- G FMC: Comply with UL 1; zinc-coated steel.
- H LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- I Multi-conductor Cable type MC and AC
 - 1. Use of MC cable is permitted under the following circumstances only:
 - a. Lighting Fixture whips (six feet or less).
- J Electrical nonmetallic tubing (ENT or "blue tube") and liquid-tight flexible nonmetallic conduit (LFNC) are not acceptable for use under any circumstances unless specifically approved in writing by the Engineer.
- K Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Set Screw – indoors; compression - outdoors.
 - 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
 - 4. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- L Joint Compound for IMC, ARC, or GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A Manufacturers: Subject to compliance with requirements, products of all manufacturers are acceptable provided they are sunlight resistant and UL listed and labeled as defined in NFPA 70 and marked for intended location and application. Conduit and fittings shall be obtained from the same manufacturer.
- B RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- C Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
- D Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman; a Pentair company.
 - 3. Square D; a brand of Schneider Electric.
- B Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D Wireway Covers: Screw-cover type unless otherwise indicated.
- E Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

- A Listing and Labeling: Surface raceways shall be UL listed and labeled as defined in NFPA 70 and marked for intended location and application.
- B Surface Metal Raceways: 5200 series aluminum with snap-on covers complying with UL 5. Manufacturer's standard satin anodized finish. Provide dividers as required to separate systems of different voltages.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems Division.
 - b. Panduit Corp.
 - c. Wiremold / Legrand.

2.5 POKE THRU ASSEMBLIES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
 - 3. Thomas & Betts Corporation.
 - 4. Wiremold Company (The).

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B Poke-Thru Assemblies:

1. Factory-fabricated and -wired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
2. Poke-thru box fittings shall maintain a minimum two-hour fire rating.
3. Comply with UL 514 scrub water exclusion requirements.
4. Service Outlet Assembly: Flush type with services indicated.
5. Selected to fit nominal 4-inch (100-mm) cored holes in floor and matched to floor thickness.

2.6 BOXES, ENCLOSURES, AND CABINETS

A Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Adalet.
2. Cooper Crouse-Hinds.
3. EGS/Appleton Electric.
4. FSR Inc.
5. Hoffman; a Pentair company.
6. Hubbell Incorporated; Killark Division.
7. O-Z/Gedney; a brand of EGS Electrical Group.
8. RACO; a Hubbell Company.
9. Spring City Electrical Manufacturing Company.
10. Thomas & Betts Corporation.
11. Wiremold / Legrand.

B General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

C Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

E Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F Metal Floor Boxes:

1. Material: Sheet metal, 11 gauge.
2. Type: Flush. Cover with 0.25" square aluminum flange rated for carpet/tile installations. Provide pour pan accessory for on grade installations.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled UL 514A.

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- G Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- H Sheet Metal Pull and Junction Boxes 100 cu. in. and smaller: NEMA OS 1.
- I Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- J Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- K Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- L Cabinets:
 - 1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

PART 3 EXECUTION

3.1 RACEWAY APPLICATION

- A Where electro-galvanized steel (EMT) is identified for use, it may be substituted by aluminum EMT for trade sizes 1-1/2" and above.
- B Outdoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed Conduit: GRC, IMC, or RNC, Type EPC-80-PVC.
 - 2. Concealed Conduit, Aboveground: IMC, EMT, or RNC, Type EPC-40-PVC.
 - 3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried or concrete encased as indicated.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- C Indoors: Apply raceway products as specified below unless otherwise indicated:

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1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC.
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Feeders over 600 V: GRC.
 7. Damp or Wet Locations: GRC or IMC.
 8. Tunnels: GRC.
 9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
 10. All BSL-3 lab conduits to be rigid galvanized steel conduit with threaded connections with threaded hubs on boxes and seal offs where conduit penetrates the BSL-3 room walls/ceiling
- D Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- E Mixing different types of conduits indiscriminately in the same system is prohibited.
- F Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use setscrew (indoors) or compression (outdoors), steel fittings. Comply with NEMA FB 2.10.
 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- G Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- H Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- I Install surface raceways only where indicated on Drawings.
- J Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

- A Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

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- B Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C Installation of all new conduits must be minimum 12 inches from ceiling grid except where approved by Owner.
- D Complete raceway installation before starting conductor installation.
- E Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems" for hangers and supports.
- F Arrange stub-ups so curved portions of bends are not visible above finished slab.
- G Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.
- H Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- I Support conduit within 12 inches (300 mm) of enclosures to which attached.
- J Raceways Embedded in Slabs:
 - 1. No conduits are to be routed in slab on grade or elevated slabs.
- K Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- L Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- M Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- N Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

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- O Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- P Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- Q Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- R Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- S Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
 - 3. Non-metallic surface raceways shall not be installed in patient care areas.
- T Install raceway sealing fittings at accessible locations according to NFPA 70 and at BSL-3 lab penetrations. Fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- U Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- V Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- W Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).

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2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) temperature change.
 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.00078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- X Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC in damp or wet locations not subject to severe physical damage.
 3. Use a maximum of 72 inches (1830 mm) of FMC for recessed and semi-recessed luminaires.
 4. Final connections to motors or equipment subject to vibration, noise transmission, or movement shall use FMC not exceeding four feet in length.
 5. Short lengths of FMC shall be used for final primary and secondary connections to Low Voltage transformers (???600V).
- Y Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- Z Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- AA Do not install boxes back-to-back in walls. Provide minimum 6-inch separation in non-fire-rated walls. Provide minimum 24-inch horizontal separation in acoustic-rated walls.
- BB Boxes shall be secured between two studs. Boxes connected to one stud are not permitted.

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CC Locate boxes so that cover or plate will not span different building finishes.

DD Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

EE Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

FF Set metal floor boxes level and flush with finished floor surface.

GG Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

A Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Sections and Owner Fire Protection Group.

1. Products: Cooper B-Line, 3M, Hilti, Specified Technologies, Inc.

3.5 IDENTIFICATION

A Junction boxes of different systems shall be identified by colors indicated below. Box and cover shall be painted prior to attaching identification labels.

B Provide permanent nameplates for all pull and junction boxes identifying circuits, voltage, and source.

3.6 PROTECTION

A Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

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SECTION 260543
UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
 - 1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
 - 2. Handholes and boxes.
 - 3. Manholes.

1.3 DEFINITION

- A RNC: Rigid nonmetallic conduit.

1.4 ACTION SUBMITTALS

- A Product Data: For the following:
 - 1. Duct-bank materials, including separators and miscellaneous components.
 - 2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Accessories for manholes, handholes, boxes, and other utility structures.
 - 4. Warning tape.
- B Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Shop drawings shall be sealed by a Professional Engineer. Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Reinforcement details.
 - 3. Frame and cover design and manhole frame support rings.
 - 4. Ladder details.
 - 5. Grounding details.
 - 6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - 7. Joint details.

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- C Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
 - 1. Duct entry provisions, including locations and duct sizes.
 - 2. Cover design.
 - 3. Grounding details.
 - 4. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 QUALITY ASSURANCE

- A All products shall be UL labeled for their intended use.
- B Comply with ANSI C2.
- C Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- B Lift and support precast concrete units only at designated lifting or supporting points.

1.7 COORDINATION

- A Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes.

PART 2 PRODUCTS

2.1 CONDUIT

- A Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

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- B RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A Manufacturers: Subject to compliance with requirements, products of all manufacturers are acceptable provided they are sunlight resistant and UL listed for the intended installation. Conduit and fittings shall be provided from the same manufacturer whenever possible.
- B Duct Accessories:
1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
 2. Warning Tape: Underground-line warning tape specified in Division 26 Section 260553 "Identification for Electrical Systems."

2.3 HANDHOLES AND BOXES

- A Description: Comply with SCTE 77.
1. Color: Gray.
 2. Configuration: Units shall be designed for flush burial and have open or closed bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, as indicated for each service.
 6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 7. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.
- B Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. Highline Products
 - c. Quazite, Hubbell Power Systems.

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2.4 PRECAST MANHOLES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Lindsey Concrete Products.
 2. Mack Industries.
 3. Norwalk Concrete Industries.
 4. Oldcastle Precast, Inc.
- B Comply with ASTM C 858, with structural design loading as specified in Part 3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.
1. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
- C Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.
- D Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.5 UTILITY STRUCTURE ACCESSORIES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bilco Company (The).
 2. East Jordan Iron Works, Inc.
 3. McKinley Iron Works, Inc.
 4. Neenah Foundry Company.
 5. Pennsylvania Insert Corporation.
 6. Underground Devices, Inc.
- B Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

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1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches (737 mm).
 - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
 - c. Covers shall have locking provisions.
 2. Cover Legend: Cast in. Selected to suit system.
 - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
 - c. Legend: "SIGNAL" for communications, data, and telephone duct systems.
 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
 - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
- C Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- D Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
 1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
- E Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
 1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
- F Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (32 mm) minimum at base.
 1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
- G Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
 1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of 9 holes for arm attachment.
 2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (508 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

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- H Duct-Sealing Compound: Non-hardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- I Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.
- J Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N). Two required.

2.6 SOURCE QUALITY CONTROL

- A Test and inspect precast concrete utility structures according to ASTM C 1037.
- B Non-concrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 2. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

- A Minimum conduit/duct size for underground installations shall be one inch.
- B Ducts for Electrical Cables over 600 V: RNC, NEMA Type EPC-40 PVC, in concrete-encased duct bank, unless otherwise indicated.
- C Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40 PVC, in concrete-encased duct bank, unless otherwise indicated.
- D Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40 PVC, in direct-buried duct bank, unless otherwise indicated.
- E Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40 PVC, in direct-buried duct bank, unless otherwise indicated.

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- F Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40 PVC, in concrete-encased duct bank, unless otherwise indicated.
- G Underground Ducts Crossing Paved Paths, Walks, Driveways and Roadways: RNC, NEMA Type EPC-40 PVC, encased in reinforced concrete.
- H A nylon pull cord shall be installed and tied off in each duct, including spares. The nylon pull cord shall have a minimum tensile strength of 200 pounds.

3.2 UNDERGROUND ENCLOSURE APPLICATION

- A Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20; Polymer concrete, SCTE 77, Tier 15 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Non-deliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10, Polymer concrete units, SCTE 77, Tier 8 structural load rating.
- B Manholes: Precast concrete.
 - 1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
 - 2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.3 EARTHWORK

- A Excavation and Backfill: Comply with earth moving sections in Division 31 Specifications, but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary top-soiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with plantings Sections in Division 32 Specifications.
- D Cut and patch existing pavement in the path of underground ducts and utility structures according to appropriate Division 01 Sections.

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3.4 DUCT INSTALLATION

- A Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
1. Water intrusion into buildings through ducts is not acceptable.
 2. This Contractor shall be fully responsible for corrective action necessary to insure water infiltration is eliminated.
- B Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1220 mm), both horizontally and vertically, at other locations, unless otherwise indicated.
- C Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D Duct Entrances to Manholes and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) O.C. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.
1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- E Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- F Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- G Concrete-Encased Ducts: Support ducts on duct separators.
1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately 6 inches (150 mm) between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

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2. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Concrete Sections.
3. Concreting Sequence: Place each run of concrete envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the concrete placement. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one concrete placement is necessary, terminate each in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
4. Placing Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application. Red dye shall be added to the top of the concrete during the placement.
5. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth, road crossings and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
6. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be placed without soil inclusions; otherwise, use forms.
7. Minimum Space between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 12 inches (300 mm) between power and signal ducts.
8. Depth: Depth: Install top of duct bank at 36 inches (900 mm) below finished grade, unless otherwise indicated.
9. Stub-Ups: Use manufactured PVC elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated for circuit conductors smaller than No. 1/0 AWG and under 600 volts. Extend concrete encasement throughout the length of the elbow.
10. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor for all circuit conductors over 600 volts and circuits under 600 volts with conductor size No. 1/0 AWG or larger.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
11. Warning Tape: Comply with Section 260553. Bury detectable warning tape approximately 18 inches (450 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

H Direct-Buried Duct Banks:

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1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in earth moving sections in Division 31 Specifications for pipes less than 6 inches (150 mm) in nominal diameter.
4. Install backfill as specified in earth moving sections in Division 31 Specifications.
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in earth moving sections in Division 31 Specifications.
6. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 12 inches (300 mm) between power and signal ducts.
7. Depth: Install top of duct bank at 36 inches (900 mm) below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.
9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
11. Warning Tapes: Comply with Section 260553. Bury detectable warning tape approximately 18 inches (450 mm) above all duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C 891, unless otherwise indicated.
2. Install unit level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.

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3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- B Elevations:
1. Manhole Roof: Install with rooftop at least 18 inches (450 mm) below finished grade.
 2. Manhole Frame: In paved areas and traffic-ways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
 3. Install handholes with bottom below the frost line, -Insert depth of frost line below grade at Project site- below grade.
 4. Handhole Covers: In paved areas and traffic-ways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
 5. Where indicated, cast handhole cover frame integrally with handhole structure.
- C Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- D Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
- E Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days. Joint between manhole and chimney shall be sealed with a flexible epoxy or EPDM rubber seal.
- F Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms as required for installation and support of cables and conductors and as indicated.
- G Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- H Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
- I Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

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3.6 INSTALLATION OF HANDHOLES AND BOXES

- A Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C Elevation: In paved areas and traffic-ways, set so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
- D Install handholes and boxes with bottom below the frost line, min 4 feet below grade.
- E Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
- F Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G For enclosures installed in asphalt paving and concrete and subject to occasional, non-deliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03 Concrete Sections with a troweled finish.
 - 2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.7 GROUNDING

- A Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A Perform the following tests and inspections and prepare test reports:

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1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
2. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

B Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

- A Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 260543

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SECTION 260544
SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes:
 - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Silicone sealants.
- B Related Requirements:
 - 1. Comply with Division 07 Sections for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 QUALITY ASSURANCE

- A All products shall be UL labeled for their intended use.
- B Comply with Fire Protection Standards.

1.4 ACTION SUBMITTALS

- A Product Data: For each type of product.
- B LEED Submittals:
 - 1. Product Data for Credit EQ 4.1: For sealants, documentation including printed statement of VOC content.

PART 2 PRODUCTS

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2.1 SLEEVES

- A Wall Sleeves:
 - 1. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water-stop unless otherwise indicated.
- B Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C Sleeves for Rectangular Openings:
 - 1. Material: Galvanized sheet steel.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Pipeline Seal & Insulator, Inc. (Link Seal).
 - 2. Sealing Elements: EPDM rubber 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.
 - 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A Description: Manufactured plastic, sleeve-type, water-stop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber water-stop collar with center opening to match piping OD.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Pipeline Seal & Insulator, Inc. (Link Seal).

2.4 GROUT

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- A Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Sealant shall have VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A Comply with NECA 1.
- B Comply with NEMA VE 2 for cable tray and cable penetrations.
- C Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Sections for joint sealants
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

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4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. De-burr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 3 inches (75 mm) above finished floor level. Install sleeves during erection of floors.
- D Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F Aboveground, Exterior-Wall Penetrations: Seal penetrations using cast-iron pipe 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.
- G Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water-stop flange to be centered in concrete slab or wall.
- C Secure nailing flanges to concrete forms.

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

END OF SECTION 260544

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SECTION 260548
VIBRATION CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
1. Isolation pads.
 2. Spring isolators.
 3. Restrained spring isolators.
 4. Channel support systems.
 5. Restraint cables.
 6. Hanger rod stiffeners.
 7. Anchorage bushings and washers.
- B Related Sections include the following:
1. Division 26 Section "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

- A The IBC: International Building Code.
- B ICC-ES: ICC-Evaluation Service.

1.4 PERFORMANCE REQUIREMENTS

1.5 ACTION SUBMITTALS

- A Product Data: For the following:
1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

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- a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
 3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
- B Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
 - a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.
 2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
 3. Field-fabricated supports.
 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacing. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 QUALITY ASSURANCE

- A Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C Comply with NFPA 70.
- D Comply with Owner Design Standards.

PART 2 PRODUCTS

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2.1 VIBRATION ISOLATORS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Isolation Technology, Inc.
 2. Kinetics Noise Control.
 3. Mason Industries.
 4. Vibration Isolation.
- B Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
1. Resilient Material: Oil- and water-resistant neoprene -MAKE A SELECTION-.
- C Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- D Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 FACTORY FINISHES

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- A Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot-dip galvanized metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 FIELD QUALITY CONTROL

- A Perform tests and inspections.
- B Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

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2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

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

D Prepare test and inspection reports.

3.4 ADJUSTING

A Adjust isolators after isolated equipment is at operating weight.

B Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C Adjust active height of spring isolators.

D Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

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SECTION 260553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes:
 - 1. Identification for raceways.
 - 2. Identification of power and control cables.
 - 3. Identification for conductors.
 - 4. Underground-line warning tape.
 - 5. Warning labels and signs.
 - 6. Instruction signs.
 - 7. Equipment identification labels.
 - 8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

- A Product Data: For each electrical identification product indicated.
- B Provide scaled electronic .pdf proofs of all Equipment Identification Labels for review prior to processing and application.
 - 1. Manufacturer provided Equipment Identification Labels shall not be used.

1.4 QUALITY ASSURANCE

- A Comply with ANSI A13.1.
- B Comply with NFPA 70.
- C Comply with NFPA 99.
- D Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

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- E Comply with ANSI Z535.4 for safety signs and labels.
- F Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

PART 2 PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- A Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B Colors for Raceways Carrying Circuits at more than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch-(75-mm-) high letters.
- C Colors for Raceways Carrying Circuits at 600 V or Less and conduits larger than two inches:
 - 1. Black letters on a white field.
 - 2. Legend: Indicate voltage and system or service type.
- D Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less and conduits larger than two inches: Slit, pre-tensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F Colors for Raceways Carrying Circuits at 600 V or Less and conduits two inches and less:
 - 1. Comply with Section 260533.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

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- C Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A Color-Coding Conductor Tape: Colored, self-adhesive vinyl tapes not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- D Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.4 FLOOR MARKING TAPE

- A 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

2.5 UNDERGROUND-LINE WARNING TAPE

- A Tape:
 - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 - 4. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - 5. Overall Thickness: 5 mils (0.125 mm).
 - 6. Foil Core Thickness: 0.35 mils (0.00889 mm).
 - 7. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
 - 8. 3-Inch (75-mm) Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).

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B Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.6 WARNING LABELS AND SIGNS

A Comply with NFPA 70 and 29 CFR 1910.145.

B Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

C Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

D Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 48 INCHES (1220 MM)."
3. Flash Protection Field Marking: All panelboards, switchgear, switchboards, panelboards motor control centers, motor control panels and electrical control panels shall be provided with a black on yellow warning sign per ANSI Z535.4 and ISO 3864. The sign shall read: "DANGER! ARC FLASH and SHOCK HAZARD. FOLLOW ALL REQUIREMENTS IN NFPA70E FOR SAFE WORK PRACTICES and PERSONAL PROTECTIVE EQUIPMENT." The sign shall be prominently mounted on the front of the equipment and readily visible. If the equipment has multiple removable front covers, a sign shall be mounted on each cover. For flush mounted panelboards in finished spaces, the sign shall be mounted on the inside of the door or inside cover. Manufacturers' standard labels are not acceptable.

2.7 INSTRUCTION SIGNS

A Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.

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3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.8 EQUIPMENT IDENTIFICATION NAMEPLATES

A Engraved, Laminated Acrylic or Melamine Nameplate: Minimum letter height shall be as indicated on drawing details. Refer to Drawings for Nameplate Details.

B Fasteners for nameplates: stainless steel screws that do not change the NEMA or NRTL rating of the enclosure, adhesive labels shall not be used.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A Paint: Comply with requirements in painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

B Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 EXECUTION

3.1 INSTALLATION

A Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

B Apply identification devices to surfaces that require finish after completing finish work.

C Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

D Attach signs and plastic labels with mechanical fasteners appropriate to the location and substrate.

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- E System Identification Color-Coding Bands for Raceways Larger than Two Inches: Each color-coding band shall completely encircle conduit. Locate bands at changes in direction, at penetrations of walls and floors, at 30-foot maximum intervals in straight runs, and within six inches of pull or junction boxes.
- F System Identification Labels for Raceways carrying circuits above 600V: Locate labels at changes in direction, at penetrations of walls and floors, at 30-foot maximum intervals in straight runs, and within six inches of pull or junction boxes.
- G System Identification Labels for Raceways carrying circuits 600V and less: Locate labels at changes in direction, at penetrations of walls and floors, at 30-foot maximum intervals in straight runs, and within six inches of pull or junction boxes.
- H Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 18 inches overall. Comply with Section 260543.
- I Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend, system voltage, and panel/circuit number. System legends shall comply with Section 260533 – 3.5.C.
 - 1. Normal power.
 - 2. Critical branch power.
 - 3. Life safety power.
 - 4. Equipment branch power.
 - 5. UPS.
- B Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - a. Color shall be factory applied.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.

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- 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - d. Colors for 120 V circuits fed from Isolation Transformers:
 - 1) Isolated Conductor #1: Orange with at least one distinctive colored stripe other than white, green or gray.
 - 2) Isolated Conductor #2: Brown with at least one distinctive colored stripe other than white, green or gray.
 - e. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
 - f. For new work in existing buildings, the existing identification method shall be used for new conductors provided it meets all requirements of this Section and the NEC.
- C Install instructional sign including the color code for grounded and ungrounded conductors using adhesive-film-type labels.
- D Emergency Sources: A sign shall be placed at the service entrance equipment indicating the type and location of on-site emergency power sources per NEC Art. 700.
- E Elevator Disconnects: Provide "Fed From" signs indicating the location of the supply side OCPD for each elevator power source.
- F Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.
- G Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 - 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
- H Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
- 1. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- I Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

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- J Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs or Metal-backed, butyrate warning signs.
1. Comply with 29 CFR 1910.145.
 2. Identify system voltage.
 3. Apply to exterior of door, cover, or other access.
 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
 - c. Other equipment as indicated on the Drawings.
- K Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- L Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer and load shedding.
- M Equipment Identification Nameplates: On each unit of equipment, install unique designation nameplate that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply nameplates to Switchgears, Switchboards, Distribution Panels, Panelboards, Motor Control Centers, Transformers, Individual Starters, Contactors, Disconnect Switches, Transfer Switches, Control Panels and Similar Equipment. Systems include power, lighting, and control systems unless equipment is provided with its own identification.
1. Refer to Drawing Details for Equipment Identification Nameplate requirements.
 2. Colors for equipment nameplates:
 - a. NORMAL power system: black letters on white background.
 - b. CRITICAL BRANCH power system: white letters on red background.
 - c. LIFE SAFETY power system: white letters on red background.
 - d. EQUIPMENT EMERGENCY power system: white letters on red background.
 3. Labeling Instructions:
 - a. Identify the piece of equipment, the source, voltage characteristics, and the load served
 - b. Indoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - c. Outdoor Equipment: Engraved, laminated acrylic or melamine nameplate. Unless otherwise indicated, provide a single line of text with one-inch- (26-mm-) high letters on 3-inch- (76-mm-) high label; where two lines of text are required, use labels 4 inches (100 mm) high.
 - d. Elevated Components: Increase sizes of nameplates and letters to those appropriate for viewing from the floor.

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- e. Fasten nameplates with appropriate stainless steel screws that do not change the NEMA or NRTL rating of the enclosure. Stick-on or adhesives are not acceptable unless the NEMA enclosure rating is compromised, then only epoxy adhesive shall be used to attach nameplates.

END OF SECTION 260553

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SECTION 260573
ELECTRICAL SYSTEM STUDIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes computer-based, fault-current studies, overcurrent protective device coordination studies, and arc-flash analysis. Protective devices shall be set based on results of the protective device coordination study.
- B Coordination of work: Contractor is responsible to supply electrical equipment fully rated for the available fault current, and shall also be responsible to ensure proper AIC ratings for protection of electrical equipment.
 - 1. Use of Series rated equipment is strictly prohibited
 - 2. Any equipment purchased prior to the completion and acceptance of the studies set forth by this specification that DOES NOT meet the requirements of said specification shall be replaced by the contractor at no additional cost to the Owner.
 - 3. Adjustment of protective device equipment as recommended by the approved coordination study submittal shall be the responsibility of the Division 26 Contractor at no additional cost to the Owner.
- C Scope of Work:
 - 1. In addition to studies as described in this specification, purpose of studies will also include satisfying the following design requirements:
 - a. Selective coordination of overcurrent protective devices upstream of elevator controllers per NEC Article 620.62.
 - b. Selective coordination of overcurrent protective devices subject to NEC Article(s) 700 and 701 when on either utility or alternate power source.
 - c. Selective coordination of overcurrent protective devices for overcurrent protective devices with adjustable settings.
 - d. Selective coordination of ground fault interrupt (GFI) trip settings for overcurrent protective devices with adjustable settings.

1.3 ACTION SUBMITTALS

- A The following submittals shall be made after the approval process for system protective devices has been completed.

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1. Coordination-study input data, including completed computer program input data sheets.
2. Study and Equipment Evaluation Reports.
3. System One Line Diagram.
4. Overcurrent protective device coordination-Study Report, Fault current study, and arc flash hazard analysis; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.4 INFORMATIONAL SUBMITTALS

- A Qualification Data: For coordination-study specialist.
- B Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

1.5 QUALITY ASSURANCE

- A Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.
- B Coordination-Study Specialist Qualifications: An entity experienced in the application of computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 1. Professional engineer, licensed in the state where Project is located, shall be responsible for the study. All elements of the study shall be performed under the direct supervision and control of engineer.
- C Comply with IEEE 242 for short-circuit currents and coordination time intervals.
- D Comply with IEEE 399 for general study procedures.
- E Comply with IEEE 1584 for Arc Flash Hazard study procedures.
- F Comply with Owner Design Standards.

1.6 CLOSE-OUT SUBMITTALS

- A Computer software model deliverable to owner

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1. The computer software model used to develop and complete all calculations associated with the Electrical System Studies included with this specification shall be provided to the Owner as part of this specification. This model shall include all accurate system components matching what was installed under the scope of this contract including but not limited to Electric Utility contributions, Switchgear, Switchboards, Busway, conduits and conductors, panelboards, transformers, over-current devices, etc. All adjustable settings shall be set in model to meet the requirements of "Coordination Study" portion of this specification.

PART 2 PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A Computer Software Developers: Subject to compliance with requirements, provide products by one of the following:
 1. SKM Systems Analysis, Inc. (Power Tools for Windows)
 2. etap
 3. EZ Power.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

- A Comply with IEEE 399.
- B Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- C Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
 1. Optional Features:
 - a. Arcing faults.
 - b. Simultaneous faults.
 - c. Explicit negative sequence.
 - d. Mutual coupling in zero sequence.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

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1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A Gather and tabulate the following input data to support coordination study:
1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Impedance of utility service entrance.
 3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
 - a. Circuit-breaker and fuse-current ratings and types.
 - b. Relays and associated power and current transformer ratings and ratios.
 - c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.
 - d. Generator kilovolt amperes, size, voltage, and source impedance.
 - e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
 - f. Busway ampacity and impedance.
 - g. Motor horsepower and code letter designation according to NEMA MG 1.
 4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Generator thermal-damage curve.
 - e. Ratings, types, and settings of utility company's overcurrent protective devices.
 - f. Special overcurrent protective device settings or types stipulated by utility company.
 - g. Time-current-characteristic curves of devices indicated to be coordinated.
 - h. Manufacturer, frame size, interrupting rating in amperes RMS symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes RMS symmetrical.

3.3 FAULT-CURRENT STUDY

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- A Calculate the maximum available short-circuit current in amperes RMS symmetrical at circuit-breaker positions of the electrical power distribution system. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:
1. Utility's supply termination point.
 2. Incoming Medium-voltage switchgear.
 3. Medium-voltage controllers.
 4. Unit substation primary and secondary terminals.
 5. Low voltage switchgear and switchboards.
 6. Motor-control centers.
 7. Distribution panelboards.
 8. Branch circuit panelboard.
 9. Generators and automatic transfer switches.
- B Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.
- C Calculate momentary and interrupting duties on the basis of maximum available fault current.
- D Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.
1. Transformers:
 - a. ANSI C57.12.10.
 - b. ANSI C57.12.22.
 - c. ANSI C57.12.40.
 - d. IEEE C57.12.00.
 - e. IEEE C57.96.
 2. Medium-Voltage Circuit Breakers: IEEE C37.010.
 3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
 4. Low-Voltage Fuses: IEEE C37.46.
- E Study Report:
1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.
 2. Show interrupting (5-cycle) and time-delayed currents (6 cycles and above) on medium- and high-voltage breakers as needed to set relays and assess the sensitivity of overcurrent relays.
- F Equipment Evaluation Report:
1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.

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3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

3.4 PROTECTIVE DEVICE COORDINATION STUDY

- A Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.
 1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
 2. Calculate the maximum and minimum interrupting duty (5 cycles to 2 seconds) short-circuits currents.
 3. Calculate the maximum and minimum ground-fault currents.
- B Comply with IEEE 242 recommendations for fault currents and time intervals.
- C Comply with NEC Article 700 requirements for selective coordination of overcurrent protective devices in the supply side of emergency system.
- D Transformer Primary Overcurrent Protective Devices:
 1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- E Motors served by voltages more than 600 V shall be protected according to IEEE 620.
- F Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- G Coordination-Study Report: Prepare a written report indicating the following results of coordination study:
 1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
 - a. Device tag.
 - b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
 - c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
 - d. Fuse-current rating and type.

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- e. Ground-fault relay-pickup and time-delay settings.
- 2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - a. Device tag.
 - b. Voltage and current ratio for curves.
 - c. Three-phase and single-phase damage points for each transformer.
 - d. No damage, melting, and clearing curves for medium and low voltage fuses.
 - e. Cable damage curves.
 - f. Transformer inrush points.
 - g. Maximum fault-current cutoff point.
 - h. Medium voltage equipment relays.

H Completed data sheets for setting of overcurrent protective devices.

3.5 ARC FLASH HAZARD ANALYSIS

- A Perform analysis using approved computer software program. The worst case operating scenario shall be the basis for the calculations. Prepare a written report in conjunction with results of fault-current study.
- B Submit results in tabular form, include bus/device name, fault current levels, flash protection boundary distances, PPE classes and AFIE levels.
- C Provide equipment labels to meet the requirements of the current version of NFPA 70E for incident energy analysis.

END OF SECTION 260573

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SECTION 260800

COMMISSIONING OF ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this section.
- B. The OPR and BOD documentation are included by reference for information only.
- C. Division 01 section 'LEED Requirements' for additional LEED requirements.

1.2 SUMMARY

- A. This section includes commissioning process requirements for Electrical systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 DESCRIPTION

- A. Refer to Division 01 Section "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's role.
- B. Refer to Division 01 Section "Submittals" for specific requirements. In addition, provide the following:
- C. Certificates of readiness
- D. Certificates of completion of installation, prestart, and startup activities.

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E. O&M manuals

F. Test reports

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the electrical contractor of Division 26 shall ultimately be responsible for all standard testing equipment for the electrical systems and controls systems in Division 26. A sufficient quantity of two-way radios shall be provided by each contractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price to the Owner and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process as needed. Proprietary test equipment (and software) shall become the property of the Owner upon completion of the commissioning process.
- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Owner.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

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PART 3 - EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare Pre-Functional Checklists for all commissioned components, equipment, and systems
- B. **Red-lined Drawings:** The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings. The contracted party, as defined in the Contract Documents will create the as-built drawings.
- C. **Operation and Maintenance Data:** Contractor will provide a copy of O&M literature within 45 days of each submittal acceptance for use during the commissioning process for all commissioned equipment and systems. The CxA will review the O&M literature once for conformance to project requirements. The CxA will receive a copy of the final approved O&M literature once corrections have been made by the Contractor.
- D. **Demonstration and Training:** Contractor will provide demonstration and training as required by the specifications. A complete training plan and schedule must be submitted by the Contractor to the CxA four weeks (4) prior to any training. A training agenda for each training session must be submitted to the CxA one (1) week prior the training session

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Perform commissioning tests at the direction of the CxA.
- B. Attend construction phase controls coordination meetings.
- C. Participate in Electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CA.
- D. Provide information requested by the CxA for final commissioning documentation.
- E. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- F. Prepare preliminary schedule for Electrical system orientations and inspections, operation and maintenance manual submissions, training sessions, equipment start-up and task completion for owner. Distribute preliminary schedule to commissioning team members.
- G. Update schedule as required throughout the construction period.
- H. Assist the CxA in all verification and functional performance tests.
- I. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

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- J. Gather operation and maintenance literature on all equipment, and assemble in binders as required by the specifications. Submit to CxA 45 days after submittal acceptance.
- K. Coordinate with the CxA to provide 48-hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- L. Notify the CxA a minimum of two weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- M. Participate in, and schedule vendors and contractors to participate in the training sessions.
- N. Provide written notification to the CM/GC and CxA that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Lighting Controls
 - 2. Switchgear
 - 3. Switchboards/Main Distribution Panel/Motor Control Centers (≥800 Amps)
 - 4. Transformers
 - 5. Generators
 - 6. Automatic Transfer Switches
 - 7. Uninterrupted Power Supplies
 - 8. Paralleling Gear
 - 9. Fire Alarm System (Witness)
- O. The equipment supplier shall document the performance of his equipment.
- P. Provide a complete set of red-lined drawings to the CxA prior to the start of Functional Performance Testing.
- Q. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
- R. Refer to Division 01 Section "General Commissioning Requirements" for additional Contractor responsibilities.

3.3 OWNER'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Owner's Responsibilities.

3.4 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for Design Professional's Responsibilities.

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3.5 CxA'S RESPONSIBILITIES

- A. Refer to Division 01 Section "General Commissioning Requirements" for CxA's Responsibilities.

3.6 TESTING PREPARATION

- A. Certify in writing to the CxA that Electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that Electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that testing procedures have been completed and that testing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of Electrical testing shall include the entire Electrical installation, from the incoming power equipment throughout the distribution system. Testing shall include measuring, but not limited to resistance, voltage, and amperage of system(s) and devices.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA along with the Electrical contractor and other contracted subcontractors, including the fire alarm Subcontractor shall prepare detailed testing plans, procedures, and checklists for Electrical systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and

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document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the Electrical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 ELECTRICAL SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. **Equipment Testing and Acceptance Procedures:** Testing requirements are specified in individual Division 26 sections. Provide submittals, test data, inspector record, infrared camera and certifications to the CA.
- B. **Electrical Instrumentation and Control System Testing:** Field testing plans and testing requirements are specified in Division 26 Sections "Instrumentation and Control" and "Sequence of Operations" Assist the CxA with preparation of testing plans.
- C. **Emergency Generator Testing and Acceptance Procedures:** Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- D. **Fire Detection and Alarm System Testing:** Provide technicians, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- E. **Electrical Distribution System Testing:** Provide technicians, load banks, infrared cameras, instrumentation, tools and equipment to test performance of designated systems and devices at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested
- F. **Vibration and Sound Tests:** Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.
- G. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
 - 1. Lighting Controls
 - 2. Switchgear
 - 3. Switchboards/Main Distribution Panel/Motor Control Centers (≥800 Amps)

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4. Transformers
5. Generators
6. Automatic Transfer Switches
7. Uninterrupted Power Supplies
8. Paralleling Gear
9. Integrated Power Loss Test
10. Fire Alarm System (Witness)

3.9 DEFICIENCIES/NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.

3.10 APPROVAL

- A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.

3.11 DEFERRED TESTING

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.

3.12 OPERATION AND MAINTENANCE MANUALS

- A. The Operation and Maintenance Manuals shall conform to Contract Documents requirements as stated in Division 01.
- B. Refer to Division 01 Section "General Commissioning Requirements" for the AE and CxA roles in the Operation and Maintenance Manual contribution, review and approval process.

3.13 TRAINING OF OWNER PERSONNEL

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to training.

END OF SECTION 230800

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SECTION 260923
LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes:
1. Time switches.
 2. Exterior photoelectric sensors.
 3. Indoor occupancy sensors.
 4. Wall box occupancy sensors.
 5. Wall box dimmers.
 6. Wall box dimmers/sensors.
 7. Indoor daylight sensors
 8. Emergency relay control devices.
 9. Lighting Control Panels.
- B Related Sections:
1. Section 260519 "Low Voltage Electrical Power Conductors and Cables" for wire and cabling.
 2. Section 260523 "Control Voltage Electrical Power Cables" for Low-voltage control cabling.
 3. Section 260553 "Identification for Electrical Systems."
 4. Section 260933 "Central Dimming Controls" for Architectural Dimming Systems.
 5. Section 260936 "Modular Dimming Controls" for localized dimming.
 6. Section 260943 "Network Lighting Controls" for low-voltage, manual and programmable lighting control systems.

1.3 DEFINITIONS

- A LED: Light-emitting diode.

- B PIR: Passive infrared.

1.4 SUBMITTALS

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- A Product Data: For each type of product indicated.
- B Shop Drawings: Show installation details for occupancy, photoelectric sensors and emergency relay control devices.
 - 1. Interconnection diagrams showing field-installed wiring.
 - 2. Single line diagrams.
 - 3. Submit typical wiring diagrams for all components including, but not limited to, photosensors, time switches, emergency relay control devices, occupancy sensors, and lighting control panels.
- C Field quality-control test reports.
- D Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 WARRANTIES

- A Indoor occupancy sensors, photosensors, time switches and emergency relay control devices shall have a standard five (5) year warranty.

1.6 COORDINATION

- A Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including luminaires, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.7 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to Authorities Having Jurisdiction, and marked for intended use.
- B Comply with Owner Design Standards.

PART 2 PRODUCTS

2.1 TIME SWITCHES

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Intermatic, Inc.
 - 2. Cooper Industries, Inc.

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3. TORK.

- B Electronic Time Switches: Electronic, solid state programmable units with alphanumeric display; complying with UL 917.
1. Contact Configuration: SPST.
 2. Contact Rating: 30A inductive or resistive, 240-V ac.
 3. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
 4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
 5. Astronomic Time: All channels.
 6. Battery Backup: For schedules and time clock.
- C Finish: Color to be coordinated with the Architect from manufacturer's standard colors.

2.2 EXTERIOR PHOTOELECTRIC SENSORS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Lutron.
 2. Leviton.
 3. Hubbell Building Automation.
- B Description: Solid state, with SPST dry contacts rated for 1800-VA to operate connected load, or contactor coils, complying with UL 773A.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
 2. Time Delay: 30-second minimum, to prevent false operation.
 3. Lightning Arrestor: Air gap type.
 4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.3 INDOOR OCCUPANCY SENSORS

- A Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide products by Lutron Electronics or comparable product approved by Owner.
- B General Description: Ceiling or wall mounting, solid-state type with a separate relay unit and isolated output.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable in ten (10) minute increments to a maximum setting of sixty (60) minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.

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3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the 'on' function in case of sensor failure.
 7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.
 8. Sensors shall be UL listed.
 9. Communications capability with daylighting function.
 10. Five year warranty.
 11. Fully compatible with lighting control system/dimming system and shall communicate with said system.
 12. Finish: Color to be coordinated with the Architect from manufacturer's standard colors.
- C Dual-Technology Low Voltage Type with Power Pack: Ceiling or wall mounting; detect occupancy/vacancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 3. Detection Coverage (Standard Room): 360° coverage, detect occupancy anywhere in the following areas when mounted on a 96-inch high ceiling.
 - a. Up to 1000 sq. ft. for normal range.
 - b. Up to 2000 sq. ft. for extended range.
 4. Operating Environment: Operating temperature 32°-104°F with a relative humidity (non-condensing) of 0% to 95%.
 5. Finish: Color to be coordinated with the Architect from manufacturer's standard colors.
- D Dual-Technology Line Voltage Dual Relay Type: Wall mounted for dual level control; detect occupancy/vacancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.

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3. Detection Coverage (Standard Room): 180° coverage, detect occupancy anywhere in the following areas when mounted on wall.
 - a. Up to 225 sq. ft. for utilizing dual technology.
4. Operating Environment: Operating temperature 32°-104°F with a relative humidity (non-condensing) of 0% to 95%.
5. Dual Relay.
6. Dual button.
7. Finish: Color to be coordinated with the Architect from manufacturer's standard colors.

2.4 WALL BOX OCCUPANCY SENSORS

- A Line voltage PIR technology wall-switch sensors
 1. Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide products by Lutron Electronics or comparable product approved by the Owner. Subject to compliance with requirements, provide one of the following:
 - a. Watt Stopper.
 - b. Hubbell.
 2. Description: Line Voltage Dual Technology type, 120/230/277 VAC, adjustable time delay up to 30 minutes, 180-degree field of view, UL Listed with a minimum PIR coverage area of 300 sq. ft.
 3. Operating Environment: Operating temperature 32-104 degrees F with a relative humidity (non-condensing) of 0% to 95%.
 4. Finish: Color to be coordinated with the Architect from Manufacturer's standard colors.
- B Warranty: 5 Years.

2.5 WALL-BOX DIMMERS

- A Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide products by Lutron Electronics or comparable product approved by the Owner.
- B Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- C Control: Continuously adjustable slide-to-off with single-pole or three-way switching. Comply with UL 1472.
- D LED Dimmer Switches: Modular; compatible with LED drivers; dimmer-driver combination capable of consistent dimming with low end not greater than 5 percent of full brightness.
 1. 1. Where 1% dimming-drivers are furnished, provide compatible dimming switch.
- E Fully compatible with lighting control system and dimming drivers.

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F Finish: Color to be coordinated with the Architect from Manufacturer's standard colors.

2.6 WALL-BOX DIMMERS/SENSORS

- A Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide products by Lutron Electronics or comparable product approved by the Owner.
- B LED Dimmer Switches: Modular; compatible with LED drivers; dimmer-driver combination capable of consistent dimming with low end not greater than 5 percent of full brightness.
1. 1. Where 1% dimming-drivers are furnished, provide compatible dimming switch.
- C LED Dimmer/Occupancy Switches: Lutron "Maestro" Series 0 – 10 VDC Dimmer/Sensor
1. Dimmer Switches: 0 – 10 VDC, full-wave, solid-state units with integral, quiet slide to off switches, compatible with all LED drivers.
 2. Where 1% dimming-drivers are furnished, provide compatible dimming switch.
 3. Sensor: Passive infrared (PIR) with ambient light detection learning mode.
 4. Control: Continuously adjustable slide-to-off with single-pole or three-way switching. Comply with UL 1472.
 5. Fully compatible with lighting control system and dimming drivers.

2.7 INDOOR DAYLIGHT SENSORS

- A Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide products by Lutron Electronics or comparable product approved by the Owner.
- B Ceiling-Mounted Daylight Sensor: Solid-state, light-level sensor unit with photodiode element to detect changes in lighting levels that are perceived by the eye, sensing daylight and electrical lighting levels. The unit adjusts the indoor electrical lighting levels.
1. Sensor Output: Provide data to the dimming ballast or step dimming ballast for adjusting light levels. As daylight increases, the lights are reduced.
 2. Power supply to sensor shall be 24-V dc, 150-mA, and Class 2 power source as defined by NFPA 70.
 3. Open loop basis for daylight sensor control scheme.
 4. Partially shielded for accurate detection of available daylight to prevent luminaire lighting and horizontal light component from skewing sensor detection.
 5. Light-Level Monitoring Range: 0 to 500 fc, with an adjustment for turn-on and turn-off levels within that range.
 6. Time Delay: Adjustable in ten (10) minute increments to a maximum setting of sixty (60) minutes.
 7. Low voltage class 2 wiring for low voltage communication.
 8. Indicator: LED's to indicate operation and programming mode.
 9. Sensor shall be capable of being mounted in ceiling tile or luminaire.
 10. Sensor shall have the ability to be replaced without reprogramming.
 11. UL listed.

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12. Five year warranty.
13. Fully compatible with lighting control system/dimming system and shall communicate with said system.

2.8 EMERGENCY RELAY CONTROL DEVICES

- A Internal Type: Self contained, modular, emergency power transfer device, factory mounted or field mounted within luminaire body and compatible with ballast, as manufactured by The Bodine Company, Model GTD or approved equal by Owner.
1. Emergency Connection: Operate one (1) ballast within fluorescent luminaire continuously under emergency conditions regardless of wall switch position. Connect unswitched normal and emergency circuits, and switched normal circuit to transfer device. Output to one (1) AC ballast.
 2. Fused input.
 3. Rated for 3 amps, 120/277 volts.
- B External Type: Where control of multiple luminaires is indicated, externally mounted type unit as manufactured by The Bodine Company, GTD20 or approved equal by Owner.
1. Fused input.
 2. Rated for 20 amps, 120/277 volts.
- C All devices shall be warranted for five (5) full years after date of purchase.
- D UL 924 Listed.

2.9 LIGHTING CONTROL PANELS

- A Manufacturers: Basis-of-Design Product: Subject to compliance with requirements, provide products by Crestron, Cooper ILC, Lutron.
- B UL 916 listed.
- C Control up to eight (8) single pole, 120 or 277 V individual lighting circuits. Panels can be networked together where more circuits are needed.
- D Enclosure: NEMA 1, surface or flush mounted, full length, hinged door, lockable. All controls shall be behind door.
- E Interior: Barrier for separation of high voltage (class 1) and low voltage (class 2) wiring. It shall include intelligence boards, power supply and control relays. Clock display and keypad shall be mounted on interior cabinet door for easy user access and programming.

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1. Panel shall accept up to eight single pole relays. Each relay shall be individually scheduled or can be grouped together to follow the same schedule. Relays shall be individual latching relays with 20 Amp load contacts for LED drivers and general purpose loads. Provide isolated auxiliary contacts for pilot light switching. Relays shall use quick connectors and be individually replaceable.
 2. Relays can be assigned the following Scenarios:
 - a. Manual On / Schedule Off
 - b. Schedule On / Schedule Off
 - c. Manual On / AS Switch Off
 - d. Photocell On / Photocell Off
 - e. Photocell On / Schedule Off
 - f. Astronomic On / Astronomic Off
 - g. Astronomic On / Schedule Off
 3. The lighting control panel shall provide a stagger up delay, override push buttons, pilot light outputs, and LED status light indicators for each relay or control channel.
 4. The clock shall have a backlight display, user keypad and shall provide 8 channels of time or astronomical control. Preprogrammed lighting control scenarios shall include: scheduled on/off, manual on/scheduled off, manual on/automatic switch sweep off, astronomic or photocell on/off and astronomic or photocell control with scheduled on/off. Time clock shall provide up to 42 holidays, automatic daylight savings adjustment, astronomic coordinates by major cities, and help screens. Program memory shall be non-volatile and clock shall retain time keeping during power outages for at least 48 hours.
 5. The panel shall have 8 universal switch inputs that are low voltage, self-configuring and shall not require programming to accept momentary on/ momentary off switch, push button switch (cycling), maintained switch or 24VDC signals from occupancy sensors, photocells or other interfacing devices.
 6. Occupancy sensor and time control shall be integrated to allow occupancy sensor control after hours with hold 'on' of lighting during occupancy scheduled time. During occupied time, control scenarios shall be selectable for time schedule of lighting 'on' or occupancy sensor detection of lighting on initially and then hold 'on' of lighting during occupied hours. Control shall provide selectable occupancy sensor blink warning prior to shut off and adjustable occupancy sensor time delay from the time clock keypad.
 7. After-hour interior lighting 'shut off' control shall provide a full duration override time of 1 to 240 minutes with a warning blink five minutes prior to shutting the lighting off. An impending 'shut off' will be cancelled and the override period re-initialized through the operation of any assigned switch input.
 8. After-hour interior lighting 'shut off' control may be by line voltage power interrupt control to automatic control switches. The lighting control relay panel shall provide a warning blink signal to automatic control switches, thus allowing a five-minute delay prior to shutting off lighting. The lighting 'shut off' event may be cancelled by pressing the automatic control switch push button. The lighting control panel time clock shall provide periodic lighting sweep signals to shut off automatic control switches.
- F Control Switches: Inputs shall be from two or three wire momentary low voltage switches or line voltage automatic control switches.
- G All devices shall be warranted for one (1) full year after date of purchase.

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2.10 CONDUCTORS AND CABLES

- A Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B Classes 2 and 3 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C Class 1 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 EXECUTION

3.1 INSTALLATION

- A Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including luminaires, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- B Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions. Allow six (6) feet of cable slack for sensor location adjustment.
- C Dimmers:
 - 1. Install dimmers within terms of their listing.
 - 2. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

3.2 WIRING INSTALLATION

- A Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.
- B Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- C Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

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3.3 IDENTIFICATION

- A Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
 - 1. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B Label time switches with a unique designation.

3.4 FIELD QUALITY CONTROL

- A Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B Lighting control devices that fail tests and inspections are defective Work.

3.5 ADJUSTING

- A Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."

END OF SECTION 260923

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SECTION 260943.13
DIGITAL-NETWORK LIGHTING CONTROLS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Networked Central Lighting Control systems. Systems are composed of:
1. Network integrated power switching systems.
 2. Network integrated dimming systems.
 3. Standalone power switching and dimming systems.
 4. Automation control processors.
 5. Sensors
 6. System Functions and Sequences
- B Related Sections:
1. Section 122413 Roller Window Shades
 2. Section 250800 Commissioning of Integrated Automation
 3. Section 251000 Integrated Automation Network Equipment
 4. Section 251113 Integrated Automation Network Servers
 5. Section 251313 Integrated Automation Control and Monitoring Network Supervisory Control
 6. Section 251319 Integrated Automation Control and Monitoring Network Interoperability
 7. Section 251516 Integrated Automation Software for Control and Monitoring Networks
 8. Section 260500 Common Work Results for Electrical
 9. Section 262726 Wiring Devices
 10. Section 265119 LED Interior Lighting
 11. Section 271500 Communications Horizontal Cabling
 12. Section 274100 Audio-Video Systems

1.3 REFERENCES

- A Definitions
1. Control: Effecting a change in state by one PC program onto a microprocessor or device.
 2. Scene: Predetermined light level of a single fixture or group of fixtures.
 3. DALI: Digital addressable lighting interface.
 4. RS-485: A serial network protocol complying with TIA-485-A.
 5. UTP: Unshielded twisted pair.

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B Reference Standards

1. IEEE 802.3 - IEEE Standard for Ethernet; 2022 (Corrigendum 2024).
2. NEMA PB 1 - Panelboards; 2011.
3. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
4. TIA-485 - Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems; 1998a (Reaffirmed 2012).
5. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.
6. UL 67 - Panelboards; Current Edition, Including All Revisions.
7. UL 444 - Communications Cables; Current Edition, Including All Revisions.
8. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.
9. UL 508 - Industrial Control Equipment; Current Edition, Including All Revisions.
10. UL 916 - Energy Management Equipment; Current Edition, Including All Revisions.
11. California Energy Commission (CEC):
12. CEC CCR Title 24, Part 6: California Energy Efficiency Standards for Residential and Nonresidential Buildings, California's Appliance Energy Efficiency program: Listed for lighting control devices.
13. National Fire Protection Association (NFPA):
14. Underwriters Laboratories (UL)
 - a. UL 508 – Industrial Control Equipment.
 - b. UL924 – Emergency Lighting and power Equipment.
 - c. UL1008 – Transfer Switch Equipment.

1.4 SYSTEM DESCRIPTION

- A** Web Accessible, network connected, lighting control system utilizing preset control software, central signal microprocessor, lighting control panel, and power switching modules and relays, Dimming Modules, DALI Control Modules, Sensors, User Interfaces.
- B** System Components: System includes the following addressable components:
1. Keypad controls.
 2. Touch screen controls.
 3. Remote occupancy sensors.
 4. Timed lighting.
 5. Daylight compensating lighting controls.

1.5 SUBMITTALS

- A** Product Data: For each type of product indicated.
- B** Shop Drawings: Show installation details for occupancy, photoelectric sensors and emergency relay control devices.
1. Interconnection diagrams showing field-installed wiring.

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2. Single line diagrams.
 3. Submit typical wiring diagrams for all components including, but not limited to, photosensors, time switches, emergency relay control devices, occupancy sensors, and lighting control panels.
- C Field quality-control test reports.
- D Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.6 WARRANTIES

- A Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of modular dimming controls system the fail in materials or workmanship within the specified warranty period following substantial completion.
1. Warranty Period: Commercial lighting dimmers and switches, sensors, keypads, lighting enclosures, terminal blocks, power supplies, thermostats, and control processors, when dedicated for use as part of a commercial lighting control system: 5 year warranty
 2. Manufacturer's Extended Support Service: Extended telephone support: Unlimited period.

1.7 COORDINATION

- A Contractor shall place daylight and occupancy sensors per plans to achieve optimal performance. Proper placement shall be coordinated with others in order to avoid interference with prescribed lighting levels.
- B Contractor shall provide luminaries and lamps that are compatible with the lighting control system to be installed.
- C Contractor shall locate touch screen and keypad stations as per plans.
- D Contractor shall notify engineer of record of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.
- E Coordinate integrated lighting and dimming controls with systems and components specified in the following sections:
1. Division 11 Section "Audio-Visual Equipment".
 2. Division 23 Section "Instrumentation and Control for HVAC".
 3. Division 25 Section "Integrated Automation Control of Electrical Systems".
 4. Division 26 Section "Panelboards".
 5. Division 26 Section "Wiring Devices".
 6. Division 26 Section "Lighting Control Devices".
 7. Division 26 Section "LED Interior Lighting".

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8. Division 27 Section "Communications Horizontal Cabling".
9. Division 27 Section "Audio-Video Systems"
10. Division 28 Section "Electronic Access Control and Intrusion Detection".

1.8 CLOSEOUT SUBMITTALS

- A Operating and maintenance manuals.

1.9 QUALITY ASSURANCE

- A Manufacturer Qualification: Manufacturer of network lighting controls with minimum five years record of satisfactory manufacturing and support of components comparable to basis of design system.
- B Source Requirements: Provide Network Lighting System through a single source from a single manufacturer.
- C Manufacturer Qualifications: Approved manufacturer of network lighting controls listed in this Section with minimum five years record of satisfactory manufacturing and support of components comparable to basis of design system.
1. Approval of Comparable Products: Submit the following in accordance with project substitution requirements, within time allowed for substitution review:
 - a. Product data, including certified independent test data indicating compliance with requirements.
 - b. Samples of each component.
 - c. Sample submittal from similar project.
 - d. Project references: Minimum of 5 installations not less than 5 years old, with Owner and Architect contact information.
 - e. Sample warranty.
 2. Substitutions following award of contract are not allowed except as stipulated in Division 01 General Requirements.
- D Approved manufacturers must comply with separate requirements of Submittals Article.
- E Electrical Components, Devices, and Accessories: UL listed and labeled per NFPA 70.
- F California Appliance Efficiency Listing: Provide products that comply with provisions of CEC CCR Title 24, Part 6.

1.10 PROJECT CONDITIONS

- A Environmental Conditions Range:
1. Temperature: 32 – 104 deg F (0 - 40 deg C).

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2. Relative Humidity: 10 – 90 percent, noncondensing.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Subject to compliance with requirements, provide products by one of the following Manufacturers:
 1. Crestron Electronics INC.
 2. Lutron Electronics - Quantum based system.
- B Substitutions:
 1. Bidders shall follow the procedure detailed below for requesting substitute Manufacturers for project consideration.
 2. All substitutions must be submitted in writing to the Engineer of Record within 14 days prior to bid date. If the bidders do not elect to obtain prior approval during the allotted time specified, the Owner, Architect, and Engineer and Lighting Designer have no obligation to review or consider any substituted products after the Contract award.
 3. Substitutions shall be submitted through local representatives.
 4. Proposed substitutions must be documented with a compliance review.
 5. Contractor shall pay professional fees (at current standard hourly rates) and reimburse expenses directly to all designers (Architect, Engineer, Lighting Designer, etc., as applicable.) for time spent reviewing substitutions proposed by the Contractor.
 6. Substitutions must meet lighting control design intent, and shall meet or exceed the performance of the specified products. Information shall be provided to the Architect and Engineer and the Lighting Designer indicating mechanical and electrical data, list of materials and finishes, and unit cost for use with product comparison and evaluation. Any deviations from the specified lighting control devices shall be highlighted and brought to the attention of the Architect and Engineer and the Lighting Designer. If requested, the bidder shall furnish the name and location of at least one completed project where any proposed substitute system has been installed, as well as the contact information of the Owner.
 7. If the substitution is accepted, approval will be provided in the form of an addendum to the Specifications and/or Contract Documents and issued to all prospective bidders.

2.2 GENERAL

- A Contractor shall provide system hardware that is manufactured and warranted by a single manufacturer.
- B Provide control system with compatibility for BACNET/IP.
- C System shall provide time clock functionality as well as support for multiple interface devices.

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- D System must automatically adjust for daylight savings time and leap year.

2.3 WIRED LOAD CONTROLLERS

A Product Family: Crestron Spacebuilder GLPP

1. Characteristics:
 - a. Provide 1, 2, or 3 zone lighting controllers for 0-10v zones.
 - b. Shall operate as an autonomous lighting controller for the space.
 - c. All sensors and zones within the space shall be controlled without additional equipment.
 - d. Lighting controller shall be surface-mounted. Industrial control enclosure mounts directly on two side by side 4" square electrical junction boxes, suitable for concealed locations.
 - e. Circuit Input: 100 – 277 VAC, 50/60 Hz. Input, one 16 amp.
 - f. Lighting controller shall be networked as part of the building wide lighting control system using Cresnet communication
2. Zone Outputs
 - a. 1,2, or 3 high inrush mechanically held relays for switching loads.
 - b. 1,000,000 cycle mechanically latching relays
 - c. Zero-cross arc-less high inrush
 - d. Air gap off protection on each channel
 - e. 0-10v dimming models shall include 0-10v 4 wire dimming for each channel.
3. Products
 - a. Crestron GLPP-SWCN (1 Zone Switching)
 - b. Crestron GLPP-1SW2CN (2 Zone switching)
 - c. Crestron GLPP-1SW3CN (3 Zone switching)
 - d. Crestron GLPP-DIMFLVCN-PM (1 ZONE 0-10v with Power Monitoring)
 - e. Crestron GLPP-1DIMFLV2CN-PM (2 ZONE 0-10v with Power Monitoring)
 - f. Crestron GLPP-1DIMFLV3CN-PM (3 ZONE 0-10v with Power Monitoring)

B Product Family: Crestron GLPAC

1. Characteristics
 - a. Provide 4 or 8 zone lighting controller for switching or 0-10v zones.
 - b. Unit shall operate as an autonomous lighting controller for the space.
 - c. Up to 4 occupancy sensors and photocells per space
 - d. Up to 10 devices can connect without additional power
 - e. Lighting controller shall be networked as part of the building wide lighting control system using ethernet communication
 - f. Lighting controller shall be a surface-mounted NEMA 1 industrial control enclosure, suitable for concealed locations.
2. Zone Outputs
 - a. 4 or 8 circuit inputs
 - b. 100 – 277 VAC, 50/60 HZ. 16amps each.
 - c. Barrired 4 normal and 4 emergency relays (-4E models only)
 - d. 4 or 8 zone outputs
 - e. 100,000 cycle mechanically latching relays

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- f. Air gap off protection on each channel.
- g. 0-10v 4-wire dimming for each channel (60mA max current sink)
- h. Override port for UL924 life safety applications
- i. Real time power monitoring on all channels (-PM models only)
- j. 4 normally open isolated relays (-PM models only)
- k. Chicago Plenum rated enclosure (-CP models only)
- 3. Products
 - a. Crestron GLPAC-DIMFLV4 -CP -PM (4-CH controller)
 - b. Crestron GLPAC-DIMFLV8 -CP -PM (8-CH controller)
 - c. Crestron GLPAC-DIMFLV8-4E -CP -PM (4-ch NORMAL & 4-ch emergency controller)

C Product Family: Crestron GL-IPAC

- 1. Characteristics
 - a. Provide 8 zone lighting controller for switching
 - b. Unit shall operate as an autonomous lighting controller for the space.
 - c. Up to 4 occupancy sensors and photocells per space
 - d. Up to 15 devices can connect without additional power
 - e. Lighting controller shall be networked as part of the building wide lighting control system using ethernet communication
 - f. Lighting controller shall be a surface-mounted NEMA 1 industrial control enclosure, suitable for concealed locations.
- 2. Zone Outputs
 - a. 8 circuit inputs
 - b. 100 – 277 VAC, 50/60 HZ. 16amps each.
 - c. 8 zone outputs
 - d. 100,000 cycle mechanically latching relays
 - e. Air gap off protection on each channel.
 - f. Override port for UL924 life safety applications
- 3. Products
 - a. Crestron GL-IPAC-SW8

D Product Family: CAEN, CAEN MLO

- 1. Characteristics
 - a. Panel shall be digitally addressable using serial or Ethernet communication from Control Processor Panel specified here to after.
 - b. Lighting dimmers shall be compatible with drivers / ballasts and LEDs / lamps.
 - c. Dimmers shall be provided in quantities, control types, and rated for the connected load as shown on the Contract Drawings.
 - d. Line and load phases shall be coordinated per manufacturers recommendations.
 - e. Dimming modules shall be field replaceable.
 - f. Dimming panels shall be listed to UL508.
 - g. Emergency Override: Remote override capability.
 - h. Microprocessor based control for time clock override and remote dimming.

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- i. Lighting control panels shall comply with NEMA PB 1 and UL 50 (CAN/CSA C22.2, No. 94), UL 67 (CSA C22.2, No. 29), UL 489 (CAN/CSA C22.2, No. 65), and UL 916 (CSA C22.2, No. 205).
 - j. Panel may contain Crestron 4-Series Control Processor
 - 1) Product: Crestron DIN-AP4
 - k. Panel may contain 24V power supply
 - 1) Product: Crestron DIN-PWS60
 - l. Panel may contain ethernet to serial converter
 - 1) Product: Crestron DIN-CENCN-2
2. Feed Types
- a. Reference contract drawing schedules for required feed types and breaker ratings
 - b. FEED-THROUGH (FT)
 - 1) No Branch circuit overcurrent protection.
 - c. Main Lug Only (MLO)
 - 1) 120vac 3-phase; 120/240 VAC split-phase
 - (a) 20 AMP thermal magnetic BREAKER
 - (b) AIC rated to 10,000A
 - (c) 20 breakers max per enclosure.
3. Control Modules
- a. GL-CAEN-4HSW4-KIT
 - 1) (4) 16A High Inrush Switching Outputs
 - 2) Arc-less high inrush, lifetime rated minimum 1,000,000 on/off cycles, with air gap off protection.
 - 3) 120V AC, 50/60 Hz.
 - 4) 32 degrees to 104 degrees Fahrenheit
 - 5) UL924 for emergency lighting control.
 - b. GL-CAEN-2DIMFLV8- 277-KIT
 - 1) (8) 4A 0-10V LED, fluorescent or switching outputs
 - 2) 120 – 277 V, 50/60Hz.
 - 3) 32 to 104 degrees Fahrenheit
 - 4) UL924 for emergency lighting control.
 - c. GL-CAEN-2DIMU8- 277-KIT
 - 1) (8) 4A Forward, Reverse Phase or switching outputs
 - 2) 120 – 277 V, 50/60Hz.
 - 3) 32 to 104 degrees Fahrenheit
 - 4) UL924 for emergency lighting control.
 - d. CLX-1DIMU4-HP
 - 1) (4) Forward, Reverse Phase or switching outputs.
 - 2) Up to 16A total, 10A Max per output.
 - 3) 120 V, 50/60Hz.
 - 4) 32 to 104 degrees Fahrenheit.
 - 5) UL924 for emergency lighting control.
 - e. GL-CAEN-2DIM8- 277-KIT
 - 1) (8) 4A Forward, Reverse Phase or switching outputs

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- 2) 120 – 277 V, 50/60Hz.
- 3) 32 to 104 degrees Fahrenheit
- 4) UL924 for emergency lighting control.
- f. CLX-1FAN4
 - 1) 4 Fan Control Channels
 - 2) 2 Amps Per Channel
 - 3) Module Total 8 Amps
 - 4) Load Types Ceiling Fan Motors
 - 5) 32 to 104 degrees Fahrenheit
 - 6) 120 Volts AC, 50/60Hz, single-phase
- 4. Enclosures CAEN-FT
 - a. CAEN-2x1
 - 1) 16AWG Galvanized steel backbox
 - 2) Height: 23.50 inch (596.9 mm)
 - 3) Width: 14.38 inch (365.1 mm)
 - 4) Depth: 4.00 inch (101.6 mm)
 - 5) 120-277 VAC.
 - b. CAEN-4x1
 - 1) 16AWG Galvanized steel backbox
 - 2) Height: 38.25 inch (971.6 mm)
 - 3) Width: 14.38 inch (365.1 mm)
 - 4) Depth: 4.00 inch (101.6 mm)
 - 5) 120-277 VAC.
 - c. CAEN-7x1
 - 1) 16AWG Galvanized steel backbox
 - 2) Height: 62.00 inch (1574.8 mm)
 - 3) Width: 14.38 inch (365.1 mm)
 - 4) Depth: 4.00 inch (101.6 mm)
 - 5) 120-277 VAC.
 - d. CAEN-4x2
 - 1) 16AWG Galvanized steel backbox
 - 2) Height: 38.25 inch (971.6 mm)
 - 3) Width: 25.50 inch (647.7 mm)
 - 4) Depth: 4.00 inch (101.6 mm)
 - 5) 120-277 VAC.
 - e. CAEN-7x2
 - 1) 16AWG Galvanized steel backbox
 - 2) Height: 62.00 inch (1574.8 mm)
 - 3) Width: 25.50 inch (647.7 mm)
 - 4) Depth: 4.00 inch (101 ,)
 - 5) 120-277 VAC.
- 5. Enclosures CAEN-MLO
 - a. CAEN-3x1-MLO-120/3P
 - 1) 16AWG Galvanized steel backbox

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- 2) Height: 39.65 inch (1008 mm);
- 3) Width: 16.10 inch (409 mm);
- 4) Depth: 4.98 inch (127 mm)
- 5) 120/208 AC, 225 Amps MAX.
- b. CAEN-5x1-MLO-120/3P
 - 1) 16AWG Galvanized steel backbox
 - 2) Height: 62.75 inch (1594 mm);
 - 3) Width: 16.10 inch (409 mm);
 - 4) Depth: 4.98 inch (127 mm)
 - 5) 120/208 AC, 225 Amps MAX.
- c. CAEN-5x2-MLO-120/3P
 - 1) 16AWG Galvanized steel backbox
 - 2) Height: 62.75 inch (1594 mm);
 - 3) Width: 27.25 inch (693 mm);
 - 4) Depth: 4.98 inch (127 mm)
 - 5) 120/208 AC, 225 Amps MAX.

2.4 FACEPLATES

- A Provide decorator faceplates for all keypad devices.
- B Multiple devices adjacent to door jams shall be ganged together.
- C Decorator faceplates shall be white Black and shall match in texture and color of the
- D Products:
 - 1. FP-G1-W B-S
 - 2. FP-G2-W B-S
 - 3. FP-G3-W B-S
 - 4. FP-G4-W B-S

2.5 TOUCH SCREENS

- A Widescreen active-matrix color display
 - 1. TSW-1070: 1920 x 1200 WUXGA display resolution
 - 2. TSW-770: 1280 x 800 WXGA display resolution
 - 3. TSW-570: 280 x 720 HD 720 display resolution
 - 4. TSW-570P: 720 x 1280 HD 720 display resolution
- B Capacitive touch screen display
- C Custom-programmable virtual control buttons

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- D Supports Crestron HTML5 and Smart Graphics® software custom user projects
- E Built-in Rava® SIP intercom
- F Built-in speakers and microphone
- G H.265, H.264, or MJPEG streaming video display
- H Native apps for Crestron Home™ OS, Sonos® home sound control, Zoom Rooms™ conferencing control, Microsoft Teams® online meeting solution, and various room scheduling services
- I Built-in Bluetooth® communications beacon
- J Built-in web browsing
- K Single wire Ethernet connection with PoE or PoE+ power
- L Wi-Fi® network connectivity (only available on 1070 and 770 models)
- M Dual USB 2.0 ports for room availability accessories
- N Enterprise grade security and authentication
- O Web, cloud, or device-based configuration
- P Electrical box mounting with provided mounting bracket Color: Black White. Mountable with a 1-3 gang mounting box
- Q Products
 1. Crestron TSW-770-W-S (7" white, 2-gang mounted)
 2. Crestron TSW-1070-W-S (10" white, 3-gang mounted)
 3. Crestron TSW-570P-W-S (5" white, 1-gang mounted)
 4. Crestron TSW-770-B-S (7" black, 2-gang mounted)
 5. Crestron TSW-1070-B-S (10" black, 3-gang mounted)
 6. Crestron TSW-570P-B-S (5" black, 1-gang mounted)

2.6 XPANEL INTERFACE: VIRTUAL TOUCH SCREEN

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- A Touch screen user interface, network-connected lighting management interface running on Crestron lighting control processor to provide lighting control, daylight harvesting, occupancy sensing, lighting schedules and overall adjustment to system functionality
- B Virtual touch screen is to be accessible via computer or laptop interface furnished by other.
- C Access to XPanel shall be via browser-based IP address or .EXE file application.
- D Product: Crestron XPANEL

2.7 MOBILE APP INTERFACE

- A Touch Screen via Crestron Mobile Pro® Control App for iPhone® and Android™
- B Mobile phone application for network-connected lighting management interface configured with any Crestron 4-Series lighting control processor to provide lighting control, daylight harvesting, occupancy sensing, lighting schedules and overall adjustment to system functionality, as setup and configured by certified Crestron programmer / service provider (CSP).
- C Virtual touch screen is to be accessible via iPhone® and Android™ (furnished by others)
- D Access to a modified XPanel via application interface configuration settings.
- E Product: CRESTRON-MOBILE-PRO as provided by app store associated with iPhone® and Android™ devices.

2.8 SENSORS

- A Outdoor Daylight and Color Temperature Sensor
 1. Measures true color temperature and intensity of natural sunlight.
 2. Communicates over serial to control system to match indoor lighting with the outdoors.
 3. Outdoor rated for rooftop installation.
 4. IP67 for watertight operation.
 5. CCT of 2,000K to 25,000K.
 6. 0 to 100,000 lux.
 7. 360 degree semispherical.
 8. Product: GLS-LCCT
- B Sensor Interface Module
 1. Sensor Interface Device: Integrates occupancy sensors and related sensors with control network. In separate enclosure. 4-wire bus providing 24 VDC power to network devices, with two independent sensing inputs.

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2. Product: Crestron GLS-SIM

2.9 CONTROL PROCESSOR PANEL AND DISTRIBUTION PANELS

- A Product Family – GLNET and CLP
- B Control processor Panels shall be provided in quantities and locations per the contract drawings, or as required for a fully networked lighting control system.
- C Control processor panels shall be factory assembled in a UL508 Panel shop
- D Shall include the following equipment to support lighting control devices
 - 1. Cabinets
 - a. Made of 16AWG galvanized steel
 - b. NEMA 1 rated
 - c. Product: DIN-EN
 - 2. Processors
 - a. Crestron 4-series control system
 - b. Modular architecture supports multiple simultaneous running programs.
 - c. Ethernet 10/100Base-T and Cresnet Connected
 - d. Astronomical time clock with events stored in non-volatile RAM
 - e. Native BACnet/IP with support for up to 500 BACnet objects
 - f. Built-In Web Server: IIS v.6.0
 - g. SNMP remote management.
 - h. Active Directory support.
 - i. IPv6 ready.
 - j. DHCP and DNS Support
 - k. Native Email Client
 - l. Remote Diagnostics
 - m. Remote Program Loading and Administration
 - n. SSL security plug in
 - o. Support user assigned or dynamic IP address.
 - p. Product: Crestron DIN-AP4
 - 3. Power Supplies
 - a. Provide regulated 24 VDC power supplies as required to support lighting control equipment
 - b. 120 VAC input
 - c. Product: Crestron DIN-PWS60
 - 4. Cresnet to Ethernet Bridge
 - a. 24v DC Input
 - b. IEEE 802.3 Power of ethernet connection.
 - c. Serial communication
 - d. USB 2.0 for setup.
 - e. Product: DIN-CENCN-2-POE
 - 5. Ethernet Distribution

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- a. 48V DC Input, 100-240 VAC 50/60 Hz Supply
- b. (5) 16 IEEE 802.3 Ethernet Ports
- c. 32 to 104 degrees Fahrenheit
- 6. Floor Hub
 - a. Connects up to 200 Crestron ZUMMESH-NETBRIDGE devices.
 - b. Contain astronomical time clock.
 - c. Maintenance is performed via standard web browser.
 - d. 1 rack unit mounted
 - e. Product: Crestron ZUM-FLOOR-HUB
- 7. GLNET-CN
 - a. Enclosure: DIN-EN-2X18
 - 1) 16AWG Galvanized steel backbox
 - 2) 120 Volts AC, 60 Hz
 - 3) Height: 12.32 inch (323 mm)
 - 4) Width: 14.13 inch (359 mm)
 - 5) Depth: 4.38 inch (111 mm)
 - 6) DIN Rail Detail: (2) 13.46 inch (342 mm) x 1.38 inch (35 mm) rails

2.10 PROGRAMMING AND CONFIGURATION SOFTWARE

- A Lighting system configuration software shall allow custom programming for lighting control system.
- B Lighting system configuration software shall generate custom software control interface modules for communication with compatible remote integrated systems.
- C The lighting system configuration software shall be GUI based for programming and development.
- D The custom software control interface shall include the following control data:
 - 1. Complete lighting system control functions.
 - 2. System specific control sets for sub systems and supervisory systems
 - 3. Bidirectional digital and analog data communication.
 - 4. Bidirectional serial data communication.

2.11 CONDUCTORS AND CABLES

- A Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B UTP Cable: 100-ohm, UTP. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

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- C Classes 2 and 3 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- D Class 1 Control Cable: Multi-conductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 EXECUTION

3.1 INSTALLATION

- A Prior to installation, examine work area to verify measurements, and that commencing installation complies with manufacturer's requirements.
- B Comply with requirements of Division 26 Sections "Common Work Results for Electrical."
- C Do not install network power controls until space is enclosed, HVAC systems are running, and overhead and wet work in space are complete.
- D Install network power switching controls in accordance with manufacturer's instructions.
- E Grounding: Provide electrical grounding in accordance with NFPA 70.
- F Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including luminaires, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- G Photometric sensors shall be mounted on the roof facing a northerly direction.

3.2 WIRING INSTALLATION

- A Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch (19.05 mm).
 - 1. Provide wiring of devices as recommended by the Manufacturer.
 - 2. Provide conduit from each outlet box up to the nearest accessible corridor or open area ceiling space.
- B Low voltage wiring shall be provided as recommended by the Manufacturer.
 - 1. Low voltage cabling shall be supported above accessible ceilings with J-hooks, and shall be kept separate from other system wiring.

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- C Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- D Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- E Ensure that conduit for line voltage wiring enters panel in line voltage areas and conduit for low voltage control wiring enters panel in low voltage areas. Check Manufacturer's Drawings for location of line and low voltage areas.
- F Provide an insulated bushing at each conduit stub.
- G Conduit runs shall not contain more than two 90-degree bends prior to termination unless conduit size is increased to the next trade size of that shown on the Drawings. Conduit shall not exceed three 90 degree bends regardless of size.

3.3 FIXTURE TESTING

- A A representative of the system Manufacturer shall supervise final connections, test, program, and adjust the entire system.
- B Contractor shall provide lighting control factory test reports for each fixture specified on this project
- C Test report shall include
 1. Confirmation of compatibility with control device
 2. Dimming Range
 3. Performance notations

3.4 PLUG LOAD CONTROL

- A Plug load controls as shown on the contract drawing shall be part of the lighting control system.
- B Plug loads shall operate in occupancy mode (Auto-on, Auto-off).

3.5 ENGRAVING

- A Keypad buttons shall be factory engraved using laser technology
- B Initial shipment of keypads shall be factory engraved per the sequence of operations specified herein and shown on the contract documents

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- C Custom keypad engravings shall be provided as part of the close out procedures.

3.6 BMS INTEGRATION

- A The lighting control system shall be integrated with the BMS system as specified in DIV. 25.
- B Communication shall occur using BACNET/IP Protocol.
- C Contractor shall provide licenses for each of the following objects and shared amongst the BMS system
 1. Occupancy Status
 2. Zone On/Off/Dim
 3. Photocell reading
- D The lighting control system shall also accept time clocked events from the BMS system
- E Provide necessary coordination labor for integration of all BACNET objects listed.

3.7 AV INTEGRATION

- A The lighting control system shall be integrated with the AV solutions as specified in DIV. 27
- B Refer to Specification Section 274116 Audio Visual System for requirements of inter-communication and required protocols for health monitoring and survivability. Provide code segments to the AV contractor as required by 274116.
- C Provide lighting preset programming within the lighting system code to facilitate recall of lighting scenes consistent with those required for the audio system presets.
- D Provision and enable Ethernet Intersystem Communications.
- E Verify network programming to assure communications between systems via Ethernet.
- F Coordinate and assist in the configuration of the Crestnet failover as indicated in 274116. Load programming into programming slots as required to enable effective system failover.
- G The following objects shall be shared with the AV system:
 1. Occupancy Status
 2. Zone On/Off/Dim
 3. Photocell reading
 4. Scene preset recalls

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H Provide necessary coordination labor for integration of all AV objects listed heretofore.

3.8 SYSTEM FUNCTIONS AND SEQUENCES

- A The system shall be capable of the following lighting control functions:
1. Scene Creation: Store levels of selected fixture circuits in preset groups.
 2. Scene Recall: recall previous stored scenes.
 3. All zones off
 4. Raise/lower level of all zones
 5. Password entry for touchscreen access
 6. Room/Zone selection
 7. Raise/lower room shades
 8. Schedule events to be automatically recalled

3.9 USER INTERFACE AND CONTROL FUNCTIONS

- A The keypad interface shall be capable of the following system control functions:
1. Scene Recall
 2. Raise/Lower
 3. Off
- B Touchscreen and Virtual touch screen interfaces shall be capable of the following system control functions:
1. Password Entry
 2. Multiple levels
 3. Room/Zone selection
 4. Scene Recall
 5. Raise/Lower
 6. Shade Control
 7. Timeclock Events
 8. Customer logo and color scheme
- C Optional control sequences for advanced control:
1. Occupancy adjustments
 2. Sensor Timeout
 3. Control logic (occupancy or vacancy)
 4. Lighting Scenes
 5. Individual zone control override
 6. Timeclock adjustments
 7. Modify timeclock activation schedule
 8. Select/unselect pre-programmed timeclock events
 9. Display all timeclock events
 10. Daylight Harvesting Adjustments
 11. Low end trim

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12. Response time
13. Zone control
14. Scene Recall
15. Fade time
16. Color scene recall

3.10 TIME CLOCK EVENTS

- A The lighting control system shall have astronomical time clocked events. 6-time clock events shall be provided.
- B End user shall have the option to create additional time clock events via touch screen or XPANEL interfaces.

3.11 MANUFACTURER SUPPORTED SERVICES

- A Contractor shall coordinate meeting between Digital-Network Lighting Controls System Manufacturer, Owner, BAS system Manufacturer and other related equipment Manufacturers to discuss equipment and integration procedures.
- B Pre-wire
 1. Manufacturer trained and authorized personnel shall provide on-site visit during the rough-in stage of the installation. At this time wiring topologies and terminations shall be reviewed with the Contractor.
- C Startup
 1. Provide manufacturer's certified system startup and adjustment.
 2. Switch each load on and off with manual line test feature of the power switching module before installing processors.
 3. Perform operational testing to verify compliance with Specifications. Adjust as required.
 4. Programming for scene control and timed control shall be coordinated with the Owner and Architect during installation. The Owner shall set the parameters for the timing on and off the systems.
- D Tuning
 1. Within 3 months of the date of Substantial Completion provide onsite service to adjust the system to account for actual occupied conditions.
- E Training
 1. Within 30 days, Factory authorized service representative to instruct owner's staff to adjust, operate and maintain network power switching systems; and provide instruction using the system software.
 2. Demonstration: Schedule demonstration with Owner.

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3. Training: Train Owner's personnel to operate, maintain, and program network power switching systems.
4. Furnish set of approved submittals, and record drawings of actual installation for Owner's personnel in attendance at training session.

3.12 IDENTIFICATION

- A Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
 1. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

3.13 FIELD QUALITY CONTROL

- A Perform the following field tests and inspections and prepare test reports:
 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 2. Operational Test: Verify operation of each lighting control device and adjust time delays.
- B Lighting control devices that fail tests and inspections are defective Work.

3.14 ADJUSTING

- A Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 260943.13

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SECTION 261200
MEDIUM-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following types of transformers with medium-voltage primaries:
 - 1. Stand Alone, Pad-mounted, Liquid-filled transformers.

1.3 DEFINITIONS

- A NETA ATS: Acceptance Testing Specification.

1.4 ACTION SUBMITTALS

- A Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.
- B Material Safety Data Sheet (MSDS) for insulating fluid.
- C Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.
 - 1. Include plans and elevations showing major components and features.
 - a. Include a plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.
 - 2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include list of materials.
 - 4. Include nameplate data.

1.5 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

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1.6 QUALITY ASSURANCE

- A Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated.
 - 1. 1. Product Selection for Restricted Spaces: Drawings indicate maximum dimensions for transformers including minimum clearances between transformers and adjacent surfaces and other items. Comply with indicated maximum dimensions and minimum clearances.
- B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C Comply with IEEE C2.
- D Liquid filled: Comply with ANSI C57.12.10, ANSI C57.12.28.
- E Oil type: IEEE C57.12.70.
- F Comply with NFPA 70.
- G Comply with FM Global requirements.
- H Comply with Owner Design Standards.

1.7 DELIVERY, STORAGE, AND HANDLING

- A Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

1.8 PROJECT CONDITIONS

- A Service Conditions: IEEE C37.121, usual service conditions except for the following:
 - 1. Exposure to significant solar radiation.
 - 2. Exposure to excessively high or low temperatures.

1.9 COORDINATION

- A Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

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- B Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Provide products by one of the following:
1. Eaton Corp. Electrical Group
 2. ABB.
 3. Cooper Industries; Cooper Power Systems Division.
 4. Cutler-Hammer.
 5. Square D; Schneider Electric.
- B Basis of Design: Transformers shown on Drawings are based on equipment by the underlined manufacturer listed first above.
1. Other approved manufacturers, including those approved by substitution requests prior to bid award, are allowed on condition that the contractor provides accessories and added labor as needed to meet requirements of Contract Documents at no added cost to owner.
 2. Transformer supplied will meet or exceed the percent impedance (%Z) of the basis of design transformer.
 3. Equipment ordered, shipped, and/or installed (a) using a manufacturer not approved prior to award of bid, or (b) without owner-approved shop drawings, or (c) without owner-approved power system studies per Specification Section 26 05 73 is subject to replacement at no cost to owner.
 4. In addition, Contractor is responsible for supplying equipment that fits in the available space as shown on Contract Documents, including code and manufacturer required working and service clearances around the equipment as well as clearance and pathways for future removal and replacement of equipment as shown on Drawings.

2.2 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

- A Description: ANSI C57.12.13, ANSI C57.12.26, IEEE C57.12.00, for pad-mounted, 2-winding transformers, stainless-steel tank base, cabinet, and sills, typically installed outdoors.
- B Insulating Liquid: Less flammable, silicone-based dielectric and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be FM approved and have low toxicity and be nonhazardous.
- C Insulation Temperature Rise: 65 deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.

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- D Basic Impulse Level: 95 for 15 kV.
- E Impedance: +/- 7-1/2%.
- F Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- G High-Voltage Switch: Separately mounted 15 kV metal-enclosed fused interrupter switch complying with Section 261300.
- H Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment.
- I High-Voltage Terminations and Equipment: Live front with externally clamped, wet process, porcelain bushings and cable connectors suitable for terminating primary cable.
- J Accessories:
 - 1. Drain Valve: 1 inch (25 mm), with sampling device.
 - 2. Dial-type thermometer.
 - 3. Liquid-level gage.
 - 4. 1 inch upper filter press and filling plug.
 - 5. Pressure-vacuum gage.
 - 6. Pressure Relief Device: Self-sealing with an indicator.
 - 7. Alarm contacts for gages and thermometer listed above.
 - 8. Additional nameplate with FM approval data.
 - 9. ANSI tank grounding provisions shall be furnished in both compartments.
 - 10. Internal fusing

2.3 IDENTIFICATION DEVICES

- A Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.4 SOURCE QUALITY CONTROL

- A Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90, for liquid filled transformers.
- B Provide factory insulating liquid test reports

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PART 3 EXECUTION

3.1 EXAMINATION

- A Examine areas and conditions for compliance with requirements for medium-voltage transformers.
- B Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
- C Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Install pad mounted transformers on concrete bases designed by the Structural Engineer.
- B Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

- A Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

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- C Verify tightness and torque all accessible bolted electrical connections to manufacturer's specified values using a calibrated torque wrench. Provide a list of all torqued connections and values.

3.5 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B Perform the following field tests and inspections and prepare test reports:
 - 1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
 - 2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C Remove and replace malfunctioning units and retest as specified above.
- D Test Reports: Prepare written reports to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

3.6 FOLLOW-UP SERVICE

- A Infrared Scanning: Perform as specified in Division 26 Section "Medium-Voltage Switchgear."

END OF SECTION 261200

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SECTION 261300
METAL ENCLOSED LOAD INTERRUPTER SWITCH

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes metal-enclosed interrupter switchgear (MVS-1) with the following optional components, features, and accessories:
 - 1. Copper, silver-plated main bus at connection points.
 - 2. Surge arresters.
 - 3. Provisions for future devices.
- B Related Sections include the following:
 - 1. Division 26 Section 262713 "Electricity Metering" for Utility metering requirements.
 - 2. Division 26 Section 260573 "Electrical System Studies" for short-circuit rating of devices and for setting of overcurrent protective devices and protective relays.

1.3 DEFINITIONS

- A ATS: Acceptance Testing Specifications.
- B GFCI: Ground-Fault Circuit Interrupter.

1.4 SUBMITTALS

- A Product Data: For each type of switchgear and related equipment, include the following:
 - 1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches.
 - 2. Time-current characteristic curves for overcurrent protective devices, including fusible devices.
- B Shop Drawings: For each type of switchgear and related equipment, include the following:
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:

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- a. Tabulation of installed devices with features and ratings.
 - b. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
 - c. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
 - d. Floor plan drawing showing locations for anchor bolts.
 - e. Current ratings of buses.
 - f. Short-time and short-circuit ratings of switchgear assembly.
 - g. Nameplate legends.
 - h. Utility company's metering provisions with indication of approval by utility company.
 - 2. Wiring Diagrams: For each type of switchgear and related equipment, include the following:
 - a. Power, signal, and control wiring.
 - b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
 - c. Schematic control diagrams.
 - d. Diagrams showing connections of component devices and equipment.
 - e. Schematic diagrams showing connections to remote devices including power monitoring and control devices.
- C Source quality-control test reports.
- D Field quality-control test reports.
- E Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition include the following:
- 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

- A Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.
- B Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated.
- C Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.
- D Comply with IEEE C2.

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- E Comply with Owner's Design Standards.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.
- B Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.7 PROJECT CONDITIONS

- A Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:
 - 1. Ambient temperature not exceeding 122 deg F (50 deg C).
 - 2. Altitude of 1000 feet above sea level.
- B Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
- C Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.8 COORDINATION

- A Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
- B Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 EXTRA MATERIALS

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

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1. Fuses: Six of each type and rating used. Include spares for future transformers, control power circuits, and fusible devices.
- B Maintenance Tools: Furnish tools and miscellaneous items required for switchgear test, inspection, maintenance, and operation. Include the following:
 1. Fuse-handling tool.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Provide products by one of the following:
 1. Eaton Corp. Electrical Group
 2. Schneider Electric; Square D
 3. Siemens
- B Basis of Design: Switchgear shown on Drawings are based on equipment by the underlined manufacturer listed first above.
 1. Other approved manufacturers, including those approved by substitution requests prior to bid award, are allowed on condition that the contractor provides accessories and added labor as needed to meet requirements of Contract Documents at no added cost to owner.
 2. Equipment ordered, shipped, and/or installed (a) using a manufacturer not approved prior to award of bid, or (b) without owner-approved shop drawings, or (c) without owner-approved power system studies per Specification Section 26 05 73 is subject to replacement at no cost to owner.
 3. In addition, Contractor is responsible for supplying equipment that fits in the available space as shown on Contract Documents, including code and manufacturer required working and service clearances around the equipment as well as clearance and pathways for future removal and replacement of equipment as shown on Drawings.

2.2 MANUFACTURED UNITS

- A Description: Factory assembled and tested.
- B Ratings: Suitable for application in 3-phase, 60-Hz, solidly grounded-neutral system.
- C System Voltage: 13.2 kV nominal; 15 kV maximum.

2.3 METAL-ENCLOSED INTERRUPTER SWITCHGEAR

- A Comply with IEEE C37.20.3.

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- B Comply with IEEE C37.20.7.
- C Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
- D Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum-rated voltage specified.
- E Main-Bus Rating: 1200 A, continuous.
- F Interrupter Switches: Stationary, 3-pole, gang-operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
 - 1. Rating: 600 -A continuous duty and load break.
 - 2. Momentary and fault closing: 40 kA RMS sym.
 - 3. Rated short time short circuit current: 25 kA RMS sym.
 - 4. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
 - 5. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
 - 6. The speed of opening and closing the switch shall be independent of the operator, and it shall be impossible to "tease" the switch into any intermediate position under normal operation.
 - 7. A maintenance provision for slow closing the switch to check switch blade engagement and slow opening the switch to check operation of the arc interrupting contacts.
 - 8. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
 - 9. Protective Shields: Cover live components and terminals.
 - 10. Fuses: De-energized if switch is open.
 - 11. Surge Arrestors on load side of fuse.
 - 12. Ground Ball Studs shall be provided on all phase, neutral and ground bus to allow for apparatus grounding clamps during maintenance.
- G Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.
 - 1. Green-OPEN, Red-CLOSED switch position indicators (FLAGS) with the words "Open" and "Closed" in French, Spanish and English.
- H Window: High-impact viewing window that permits full view of the position of all three switch blades and arcing contacts through the closed door. The window shall not be more than 58-inches above the switch pad level to allow ease of inspection.
- I Key Interlocks: Arranged for interlocking schemes indicated.

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- J Padlocking Provisions: For installing at least three padlocks on each switch to secure its enclosure and prevent movement of drawout mechanism. Provisions shall be included for padlocking in the open or closed position.
- K Power Fuses: Comply with the following and with applicable requirements in NEMA SG 2:
 - 1. Direct acting, (175A "E" rated fuses) fuses to automatically open the manually operated load interrupter switch in the event of a blown fuse.
 - 2. Prevention of potential anti-single-phase conditions by blocking the closing of the manually operated load interrupter switch when a fuse is blown or if a fuse is not installed
 - 3. Indicator: Integral with each fuse to indicate when it has blown.
 - 4. Mounting: Positively held in position with provision for easy removal and replacement from front without special tools.
 - 5. Current-Limiting, E-rated Fuses: Full-range, fast-replaceable, current-limiting type rated for not less than 50-kA RMS symmetrical current-interrupting capacity that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
 - 6. Spares: Include three fuses in use and three spare fuses in storage clips in each switch

2.4 FABRICATION

- A Outdoor Enclosure: NEMA Type 3R, galvanized steel, listed for installation outdoors.
 - 1. Each compartment shall have the following features:
 - a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h) wind.
 - b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
 - c. Aisle-less construction, door-in-door construction with full height doors in front of basic weatherproof equipment, rear hinged doors for each section, all with provisions for padlocking. Downward, rearward sloping roof. Integral structural steel base frame with factory-applied undercoating.
 - d. Weatherproof GFCI duplex receptacle.
 - e. Power for heaters, lights, and receptacles to be provided by a 5 kVA fused control power transformer.
 - f. Ventilation louvers equipped with insect and rodent screen and filter, and arranged to permit air circulation while excluding rodents and exterior dust.
 - g. Provisions to extend enclosure to add feeder sections in the future.
- B Finish: Manufacturer's standard gray finish over rust-inhibiting primer on phosphatizing-treated metal surfaces. (zinc-phosphate for outdoor equipment, iron phosphate for indoor equipment, pre-treatment applied prior to paint application)
- C Outgoing Feeder Units: Arranged to suit distribution feeders.
- D Auxiliary Compartments: Arranged to house customer metering, relays, controls, and auxiliary equipment; isolated from medium-voltage components.

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- E Inspection windows in front panel of each cubicle, to permit visual inspection of the disconnect blades from outside the enclosure.

2.5 COMPONENTS

- A Main Bus: Copper, silver plated at connection points; full length of switchgear.
- B Ground Bus: Copper, silver plated or copper, tin plated; minimum size 1/4 by 2 inches (6 by 50 mm); full length of switchgear.
- C Bus Insulation: Covered with flame-retardant insulation.
- D Provisions for future extension of buswork to additional feeder sections.
- E Provide insulating boots on all cable terminations.
- F Surge Arresters: Distribution class, 12 kV, metal-oxide-varistor type. Comply with NEMA LA 1.
 - 1. Install in cable termination compartments in each phase of circuit.
 - 2. Coordinate rating with circuit voltage.
- G Control power: 5KVA CPT connected to the line side of the first switch with primary and secondary fusing.
- H Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
 - 1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
 - 2. Conductors sized according to NFPA 70 for duty required.

2.6 UTILITY COMPANY EQUIPMENT

- A Provide separate cubicles for utility metering equipment. Utility metering vertical section shall contain provisions for current transformers and voltage transformers as required by the Utility. The construction shall conform to the Utility Company's metering standards. It shall also conform to the general electrical and construction design of the switchgear specified above.
- B Provide suitable arrangements within the utility primary metering cubicles for mounting metering equipment, including drilling or tapping the bus. Obtain the Utility's approval of the cubicle arrangements prior to fabrication of the switchgear.

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- C This Contractor shall be responsible for coordinating the installation of utility metering equipment by utility personnel. Coordinate requirements with Section 262713 "Electricity Metering".

2.7 POWER QUALITY METERING

- A Provide power quality meters on main switchgear. Meters to be connected to electricity metering system and BMS system. Refer to 262713 Electricity Metering for more information.

2.8 SPACE FOR FUTURE DEVICES

- A Where indicated on the Drawings, "space" shall mean fully provisioned space ready for inserting a device at a future date without any future modifications. Provide current transformers sized according to the switch size. A blank door shall close off the front of the compartment.

2.9 IDENTIFICATION

- A Materials: Refer to Section 260553 "Identification for Electrical Systems." Identify units, devices, controls, and wiring.

2.10 SOURCE QUALITY CONTROL

- A Before shipment of equipment, perform the following tests and prepare test reports:
 - 1. Production tests on completed switchgear assembly according to IEEE C37.20.2.
- B Assemble switchgear and equipment in manufacturer's plant and perform the following:
 - 1. Functional tests of all instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current transformer secondary circuits.
- C Prepare equipment for shipment.
 - 1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
 - 2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

2.11 FACTORY FINISHES

- A Finish: Manufacturer's standard color finish applied to equipment before shipping.

PART 3 EXECUTION

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3.1 EXAMINATION

- A Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Coordinate metering requirements and installation of metering equipment with First Energy Metering Shop.
- B Anchor switchgear assembly to concrete base and attach by bolting.
 - 1. Interior location: Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated.
 - a. a. Install dowel rods to connect concrete pad to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of pad.
 - b. b. Coordinate requirements with Section 261116 "Secondary Unit Substations".
 - 2. Exterior location: Mount switchgear on concrete slabs. Unless otherwise indicated, the slab shall be at least 8 inches (200mm) thick, reinforced with a 6 by 6 inch (150 by 150-mm) No. 6 mesh placed uniformly 4 inches (100-mm) from the top of the slab. Slab shall be placed on a 6 inch (150-mm) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 4 inches (100-mm) above the finished grade. Edges shall be chamfered. The slab shall be of adequate size to project at least 8 inches (200-mm) beyond the equipment.
 - 3. Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete and reinforcement as specified in Division 03 Sections.
- C Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.
- D Install fuses in fusible switches in accordance with Division 26 Section "Electrical System Studies".

3.3 IDENTIFICATION

- A Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B Diagram and Instructions:
 - 1. Frame under clear acrylic plastic on front of switchgear.
 - a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.

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- b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
- 2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS

- A Cable terminations at switchgear are specified in Division 26 Section "Medium-Voltage Cables."
- B Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values using a calibrated torque wrench. Provide a list of all torqued connections and values.
- C Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D Connect wiring according to Division 26 Sections "Low-Voltage Electrical Power Conductors and Cables" and "Medium-Voltage Cables."

3.5 FIELD QUALITY CONTROL

- A Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect switchgear, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
 - 2. Assist in field testing of equipment.
 - 3. Report results in writing.
- C Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
 - a. Switchgear.
 - b. Surge arresters.
- D Remove and replace malfunctioning units and retest as specified above.

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- E Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each switchgear lineup. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Instrument: Use an infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial actions taken, and observations after remedial action.

3.6 ADJUSTING

- A Install fuses according to results in Division 26 Section "Electrical System Studies." Post a durable copy of the "as-left" fuse ratings in a convenient location within the switchgear.

3.7 CLEANING

- A On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.8 PROTECTION

- A Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturers' stipulated service conditions.

3.9 DEMONSTRATION

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

END OF SECTION 261300

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SECTION 262200
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
 - 1. Distribution transformers.

1.3 ACTION SUBMITTALS

- A Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
- B Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A Source quality-control test reports.
- B Field quality-control test reports.
- C Submit Letter of Compliance with NEMA TP-1 and DOE 2016.
- D Submit certification of sound level compliance.

1.5 CLOSEOUT SUBMITTALS

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- A Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."
- D Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.7 COORDINATION

- A Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Provide products by one of the following:
 - 1. Eaton Corp. Electrical Group
 - 2. Schneider Electric; Square D
 - 3. Siemens
- B Basis of Design: Transformers shown on Drawings are based on equipment by the underlined manufacturer listed first above.
 - 1. Other approved manufacturers, including those approved by substitution requests prior to bid award, are allowed on condition that the contractor provides accessories and added labor as needed to meet requirements of Contract Documents at no added cost to owner.

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2. Transformer supplied will meet or exceed the percent impedance (%Z) of the basis of design transformer.
3. Equipment ordered, shipped, and/or installed (a) using a manufacturer not approved prior to award of bid, or (b) without owner-approved shop drawings, or (c) without owner-approved power system studies per Specification Section 26 05 73 is subject to replacement at no cost to owner.
4. In addition, Contractor is responsible for supplying equipment that fits in the available space as shown on Contract Documents, including code and manufacturer required working and service clearances around the equipment as well as clearance and pathways for future removal and replacement of equipment as shown on Drawings.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B Cores: Grain-oriented, non-aging silicon steel.
- C Coils: Continuous windings without splices except for taps.
 1. Internal Coil Connections: Brazed or pressure type.
 2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

- A Comply with NEMA ST 20 and list and label as complying with UL 1561.
- B Cores: One leg per phase.
- C Enclosure: Ventilated, NEMA 250, Type 2.
 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- D Transformer Enclosure Finish: Comply with NEMA 250.
 1. Finish Color: ANSI 61 gray.
- E Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- F Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- G Energy Efficiency for Transformers Rated 15 kVA and Larger:
 1. Comply with NEMA TP 1, exceed CSL-3 efficiency levels.
 2. Tested according to NEMA TP 2.

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3. Comply with DOE 2016.

- H K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for non-sinusoidal load current-handling capability to the degree defined by designated K-factor.
1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 2. Indicate value of K-factor on transformer nameplate.
 3. The neutral bus shall be configured to accommodate 200% of the rated current.

I Wall Brackets: Manufacturer's standard brackets.

J Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 DRIVE ISOLATION TRANSFORMERS

- A Motor drive isolation transformers shall be designed for use with three-phase ac adjustable frequency drives 600 volts and below to provide isolation between the incoming line and drive circuitry. These drives minimize the line disturbances caused by SCR firing within the drive unit. Thermo-guards shall be included in all motor drive isolation transformers to provide additional protection for the transformer from increased heating due to the non-sinusoidal characteristics of drive currents. The transformer shall provide reduced short-circuit currents and voltage line transients. The transformer shall be specifically sized to the drive kVA requirements dictated by the horsepower of the motor and, as such, will be mechanically braced to withstand the stress of current reversals and short-circuit currents associated with the specific drive kVA rating. Transformers shall be low loss type with minimum efficiencies per NEMA TP-1 when operated at 35% of full load capacity.

2.5 IDENTIFICATION DEVICES

- A Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

- A Test and inspect transformers according to IEEE C57.12.91.
- B Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 EXECUTION

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3.1 EXAMINATION

- A Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
- B Construct concrete bases 4 inches high for floor mounted transformers and anchor transformers to pad according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section "Hangers and Supports for Electrical Systems."

3.3 CONNECTIONS

- A Connection to Transformers: Primary and secondary connections shall be made with Flexible Metallic Conduit (FMC).
- B Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
 - 1. External cable shall be rated 90 degrees C (sized at 75 degrees C ampacity) for encapsulated and 75 degrees C for ventilated designs. Connectors should be selected on the basis of the type and cable size used to wire the specific transformer.
 - 2. Verify tightness and torque all accessible bolted electrical connections to manufacturer's specified values using a calibrated torque wrench.

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3.4 FIELD QUALITY CONTROL

- A Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C Remove and replace units that do not pass tests or inspections and retest as specified above.
- D Infrared Scanning: after Substantial Completion, but prior to beneficial occupancy, perform an infrared scan of all transformer connections.
 - 1. Uses an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - 2. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- E Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B Output Settings Report: Prepare written report recording output voltages and tap settings.

3.6 CLEANING

- A Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

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SECTION 262313
PARALLELING LOW-VOLTAGE SWITCHBOARD

PART 1 GENERAL

1.1 SUMMARY

- A This Section includes low-voltage fixed circuit-breaker switchboard rated 1000 V and less, and associated control systems, for paralleling generators on an isolated bus and for distributing power in AC systems.
- B Related Sections include the following:
 - 1. Division 26 Section 260573 "Electrical System Studies" for short-circuit rating of devices and for setting of overcurrent protective devices.
 - 2. Division 26 Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.
 - 3. Division 26 Section 263213 "Engine Generators" for interfacing with Emergency Power Systems.

1.2 DEFINITIONS

- A ATS: Acceptance Testing Specifications.
- B HMI: Human machine interface.
- C OIP: Operator Interface Panel.
- D PSG: Paralleling Switch Gear.

1.3 ACTION SUBMITTALS

- A Product Data: For each type of switchgear and related equipment, include the following:
 - 1. Electrical characteristics, rated capacities, operating characteristics, furnished specialties, and accessories.
 - 2. Time-current characteristic curves for individual relays and overcurrent protective devices.
 - 3. Description of sequence of operation for paralleling controls.
- B Shop Drawings: Detail equipment and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.

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2. Installation, operating and maintenance manuals.

C Source quality-control test reports.

D Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A Operation and maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fuses: Six of each type and rating used. Include spares for potential transformers, control power circuits, and fusible devices.

B Maintenance Tools: Furnish tools and miscellaneous items required for switchgear test, inspection, maintenance, and operation. Include the following:

1. Floor-running transport or dock-able dolly with manual lifting mechanism and all other items necessary to remove circuit breaker from housing and transport to remote location.
2. Racking handle to move circuit breaker manually between connected and disconnected positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

1.6 QUALITY ASSURANCE

A The manufacturer shall be a well-established company regularly engaged in the application, engineering, manufacturing, integration and testing of critical electrical power control switchgear systems. The manufacturer shall have at least ten years experience in the design and manufacture of generator control power systems and automatic transfer switches. If requested, provide documentation of three similar projects in size and scope installed and operational within the last five years.

B Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated.

C Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100 by UL and marked for intended use.

D Provide circuit breakers of the same manufacturer as that specified for other electrical distribution equipment.

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- E Comply with the following:
- F NFPA 70 - National Electric Code.
- G NFPA 110 - Emergency and Standby Systems
- H NEMA PB 2 - Dead Front Distribution Switchboards
- I ANSI/IEEE C12 – Code for Electric Metering.
- J Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
- K Manufacturer Qualifications: A qualified manufacturer. Maintain, within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

1.7 PROJECT CONDITIONS

- A Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- B Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:
 - 1. Ambient temperature not exceeding 104 deg F (40 deg C).
 - 2. Altitude of not more than 6000 feet above sea level.

1.8 COORDINATION

- A Coordinate layout and installation of switchgear and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

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- A The Manufacturer shall provide a complete two-year warranty from the date of substantial completion. Any failure to comply with the contract documents or any defects that appear within the two-year period from date of shipment shall be corrected at no cost to the Owner.

PART 2 PRODUCTS

2.1 GENERATOR PARALLELING MONITOR AND CONTROL SYSTEM

- A Provide products by one of the following:
1. Russelectric (ABB)
 2. Catapillar
 3. ASCO
- B Basis of Design: Switchboard shown on Drawings are based on equipment by the underlined manufacturer listed first above.
1. Other approved manufacturers, including those approved by substitution requests prior to bid award, are allowed on condition that the contractor provides accessories and added labor as needed to meet requirements of Contract Documents at no added cost to owner.
 2. Equipment ordered, shipped, and/or installed (a) using a manufacturer not approved prior to award of bid, or (b) without owner-approved shop drawings, or (c) without owner-approved power system studies per Specification Section 26 05 73 is subject to replacement at no cost to owner.
 3. In addition, Contractor is responsible for supplying equipment that fits in the available space as shown on Contract Documents, including code and manufacturer required working and service clearances around the equipment as well as clearance and pathways for future removal and replacement of equipment as shown on Drawings.
- C The front accessd switchboard and system controls, including all breakers, bus-work, and components, shall be completely assembled by a single manufacturer, and be listed and labeled under U.L. 891 with bus withstand rating of 100,000A symmetrical for four (4) cycles minimum, by the same manufacturer, and shall consist of an engine generator control cubicle for each engine, one master control cubicle and distribution cubicles as shown on the drawings.
- D Paralleling switchgear shall be furnished to provide and control the operation of two (2) 1500 KW, 480/277 volt 3PH 4-wire generators.
- E The last generator control cubicle and distribution cubicle shall have bus sized and drilled for extension into future cubicles.
- F Paralleling switchgear dimensions shall not exceed the space provided as shown on the drawings.

2.2 SYSTEM OPERATION

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A Automatic Operation

1. The emergency generator control and distribution switchboard shall be designed to automatically control and supply the emergency generator power to the building loads. Priority 1 transfer switches would transfer when the first generator is connected to the bus. Lower priority transfer switches may be added to the emergency source by operating the block transfer over-ride function located at each transfer switch.
2. Whenever the engine generator selector switches are placed in their automatic position, with the master control switch in the automatic position, the engine generator system shall be placed on standby in readiness for automatic starting and synchronization in the event of a power failure signal from the automatic transfer system. In the event of a power failure, all engine generators shall automatically start and come up to speed. The first generator to achieve 90% of rated voltage and frequency shall be connected to the emergency bus. Priority #1 transfer switches shall be allowed to transfer to emergency. These transfer switches shall be pre-selected by engineer and shall not exceed the full load capacity of any one generator. The remaining generators shall automatically be paralleled when in synchronism. As the remaining load allows, pilot contacts shall initiate load control circuits to allow lower priority transfer switches to transfer to the emergency bus. The switchboard shall have a bus optimizer type load control system. The bus optimizer load control shall include three separate adjustable timers (load add timer below engine count, equal to engine count, and above engine count) to control the addition of load to the system based on the number of engines on-line, the KW loading on the system and the anticipated load values assigned to each load step. These values shall be adjustable through the switchboard operator interface panel.
3. Failure of any engine generator while operating in the automatic mode shall initiate load shedding control, if necessary, to reduce the total load to the capacity of the remaining generators by sending load shed signal to lower priority transfer switches in reverse order of addition. Upon receipt of a load shed signal, the transfer switches (dual operator type ATS) shall move to a center-off position. If utility power is available, the ATS shall return to utility position.
4. Upon a signal from all transfer switches that commercial power has been restored and that the transfer switches have retransferred the load to the normal source, the generator circuit breakers shall be opened simultaneously and the engine generator shall be allowed to operate at no load for an adjustable period of time. At the end of the cool-down period, all generators shall be shut down and placed in readiness for the next power failure.
5. Whenever the master control switch is placed in the "Manual" position, the entire generating plant can be operated as a manual station with starting and stopping of the engines through the "Run" positions of the engine selector switches. A swing panel shall be provided with synchroscope and synchronizing lights to aid in the manual paralleling of the generator sets. The panel shall be an integral part of the master control panel door. The swing panel shall utilize discreet components that are operable in the event of control or operator interface failures. Simulated synchroscope and lights displayed on the operator interface are not acceptable. All protection circuits shall over-ride manual operation to insure protection for the system.

B Generator Demand & Load Control Operation:

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1. A generator demand sensing program shall be provided in the master control panel to remove any excess generators from the bus when the connected load decreases. This program shall be designed to insure that an adequate spinning reserve shall be available for sudden load changes while reducing the operating hours of the system generators. The system shall allow for three selectable modes of generator demand operation: % KW Based Generator Demand, KW Based Spinning Reserve or Engine-Generator Based Spinning Reserve.
2. The programmable controller monitors the load on the emergency bus and shall initiate signals to add or subtract generators as required. In a normal power failure operation, generator demand sensing shall be, after a 0-60 minute time delay, placed into operation. An indicating lamp on the Operator Interface Panel shall be flashing during a 0-60 minute time delay and shall be on constant, when the system shall be operating in load demand mode. Initial setting to be 15 minutes
3. The engine starting and stopping sequence can be changed through the Operator Interface Panel. The start/stop sequence shall be provided to allow the operators of the system to adjust the total operating hours of each engine-generator for a planned maintenance schedule. The engine selected with a sequence register containing a value of 1 shall be the base engine; the one with a value of 2 shall be sequence position no. 2, etc. Automatic priority selection shall be based on run time
4. When the sequence is changed during an automatic operation, any engine on line shall remain on line. If the engine selected as the base engine is not on line, it shall be immediately started and placed on line. The engine-generator that is selected as sequence position no. 2 shall be the first to be added to the bus and the last to be subtracted. Should an engine be locked out of the system, it shall be skipped over and the next engine in sequence shall be started or stopped as required.
5. The set-points are field adjustable through the operator interface panel. The over-load set-point shall be adjustable from 90 to 125% of each engine's rated loading. The load increase set-point shall be adjustable from 60 to 100% (or over-load - 10% whichever is smallest) of the on line capability of the system. The load decrease set-point shall be adjustable from 40% to 80% (or increase - 10% whichever is smallest) of the on line capability of the system after the decrease.
6. The over-load and increase time delays have inverse time characteristics - the higher the loading - the shorter the time delay. The settings are programmable through the operator interface panel. The ranges are 0 to 10.0 seconds for the over-load set-point, and 0-999.99 for the increase time delay. The decrease time delay shall be adjustable from 0-999 seconds.
7. If the load on the emergency bus decreases below the load decrease set point, the programmable controller shall, after the time delay, signal the last engine-generator in sequence to be removed from the line. When a single engine generator is on bus, the decrease sensing shall be inoperative.
8. If the load on the emergency bus increases to above the increase set point, the programmable controller shall, after the time delay, signal the next engine-generator in sequence to automatically start and close to the bus. An increase load capacity pushbutton shall be provided on the Operator Interface Panel to allow an operator to immediately place the next engine-generator in sequence on line.
9. Should the load of any engine increase to above the over-load set-point, the next engine-generator in sequence shall be, after the time delay, started and placed on line. In addition to starting the next generator, non-essential loads shall be shed to relieve the load on the emergency bus.

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10. The Operator Interface Panel shall display the individual engine generator kilowatts and total system kilowatts.
11. During generator operation, an under-frequency or over-load condition shall result in load shed. Once the bus is restored to normal limits, the shed load shall be re-added. Load add and load shed signals are included for all priorities and may be adjusted through the Operator Interface Panel.
12. If the failure of a single engine does not create an over-load condition, no load shedding shall occur. If the failure of an engine generator creates an over-load condition (adjustable 90-125% of any engine's rating) and after 0-10 second time delay, the lowest priority ATS shall be shed. (Note that Priority #1 loads shall not be shed and should be within the capacity of a single engine generator.) If operating in generator demand mode, the next engine in sequence shall be started. Once the bus is restored and excess generation is available, the shed loads shall be re-added.
13. Load shedding shall be accomplished by transferring the lower priority transfer switches (RMTD Type) to a center-off position where both the normal and emergency power contacts are disconnected from the loads. If normal power is present, the switch shall go back to the normal position. Automatic re-addition of these loads shall occur as controlled by the control system. Systems using transfer switches that do not have a load shed position (disconnected from both normal and emergency power) are not acceptable.
14. Upon detecting an under-frequency condition, all available engines shall be started. Under-frequency load shedding shall operate the load control contacts similar to over-load except at a more rapid shedding rate. This feature shall insure the greatest continuity of service to the priority #1 loads. Automatic restoration of load shall occur after the bus has returned to normal frequency and the under-frequency alarm has been manually re-set. The bus under-frequency load shedding operation shall be functional even if system PLCs are inoperable.
15. An auto load control function key shall be provided on the operator interface panel. If the load control function is bypassed, this shall allow supervised loading of the engines up to their maximum rating. Should an under-frequency condition occur, the bypass shall be defeated and load shedding shall occur, as described previously.
16. Non priority one loads may be programmed for smaller steps (i.e. 2.00-2.99, 3.00-3.99, etc.). Sub-priorities shall be in effect for load shedding operation resulting from over-load condition, for automatic load control operation and for manual load control operation while using the load add and load shed non-essential load pushbuttons. This shall allow the operator more flexibility in loading up the generators while in the load control bypass mode of operation.
17. The add load pushbutton on the operator interface panel shall allow an operator to add lower priority load to the emergency generator system. Each time the pushbutton is depressed the next priority shall be added.
18. The shed load pushbutton on the operator interface panel shall allow immediate load shed of the next lowest priority non-essential load. Each time the pushbutton is depressed. The next priority load shall be shed. Priority 1 loads shall not be shed and shall be within the rating of a single generator. This pushbutton shall remain functional in both manual and automatic operation; however, in the automatic mode, any shed load shall be re-added once the button is released, provided the bus is capable of increased load.

2.3 CONSTRUCTION

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A Switchboard Framework:

1. Freestanding, floor-mounted, indoor type, NEMA 1
2. Dead front, dead rear for installation against a wall
3. Fabricated on a die-formed steel base or base assembly, welded or bolted together to rigidly support the entire shipping unit for moving on rollers and floor mounting
4. Die-piece holes for connecting adjacent sections to assure alignment and facilitate future additions
5. Bolts, nuts, and washers shall be cadmium-plated, rustproof metal.
6. Designed to withstand the mechanical stresses caused by rough handling during shipment, in addition to the electrical and mechanical stresses that occur during operation of the assemblies.
7. Framework formed of code gauge steel (12 gauge minimum) suitable for anchorage to floor.
8. Rugged steel assemblies with bracing, reinforcing gussets and jig-welding, to assure rectangular-rigidity. The sections shall be completely metal enclosed.
9. Each switchgear section shall have open bottom, as required, for ready installation and termination of conduits. Top and bottom conduit and bus duct area, if applicable, is to be clearly shown and dimensioned on the shop drawings.
10. All front panels shall be removable, attached by bolts and small enough for easy handling by one person.
11. Front access panels, bolt-on mounted, equipped with lock type operating handles, shall be installed on all cubicles for easy access.
12. Individual front doors shall be supplied for each power circuit breaker compartment. Layout shall be reviewed when shop drawings are submitted for review.
13. Suitable means shall be provided near top and bottom of switchboard to insure adequate ventilation for all equipment within the switchboard assembly.

B Dimension:

1. Conform to the arrangements and details as shown on the drawings and to the space designated for installation
2. Construct so highest operating handles do not exceed 6', 6" above floor
3. Provide adequate gutter space in all front access cable compartments of switchboard sections. Arrange for clearance to permit good accessibility of feeder conductors into switchboard.

C Painting:

1. All steel parts shall be prepared for painting by a 5-step cleaning, phosphatizing and sealing process. The parts shall then be painted ANSI 61 gray, utilizing polyester powder coating applied by the electrostatic method and cured in a baking oven. This finish shall be suitable for outdoor as well as indoor applications.

D Bus Bars and Interconnections:

1. General
 - a. All bus and stub connections shall be silver-plated copper. All bus shall be plated after bending and matching.

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- b. Size: Size such that the current density is not greater than the current carrying capacity of the rectangular copper bars, as required by U.L. and NEMA standards. Heat rise tests shall be in accordance with U.L. 891.
 - 2. Bus and stub connections shall limit temperature rise to 65oC at load current capacity at 40oC ambient.
 - 3. If a rear compartment is utilized to house any control components, grounded metal personnel protection barriers shall be provided to isolate the bus compartments.
 - 4. Bus bar and interconnection joints shall be silver-plated, constant high pressure type with Grade 5 steel, cadmium-plated, rust-proof bolts, nuts and compression washers.
 - 5. Bracing: Bus bracing capacity shall be adequately braced to withstand maximum short circuit current available. The minimum bracing shall be 100,000 amps symmetrical for 4 cycles.
 - 6. Ground Bus: 25% current carrying capacity of the engine generator control switchgear bus, which extends across the entire width of the switchboard assembly.
 - 7. Bus phase designations front to back, top to bottom, left to right, shall be A, B, C, respectively, when viewed from the front.
 - 8. Main horizontal bus bars between sections shall be located in switchboard to permit maximum conduit and wiring area.
 - 9. The continuous ampere rating of the main power bus shall be as shown on the contract drawings and the bus connections to the power circuit breakers shall match the circuit breaker frame size to which it is connected.
 - 10. All circuit breakers shall have a minimum of 65 KAIC rating
- E Compartments:
- 1. The control sections shall be isolated by grounded steel barriers from the circuit breaker and bus sections. Control voltage shall be 120 VAC or less, in these sections.
 - 2. Power circuit breakers shall be installed in individual front compartments with separate doors.
 - 3. Rear access shall not be required
- F Instrument and Control Wiring:
- 1. Instrument and control wiring within the switchboard sections shall be of flame retardant type "SIS", extra flexible, 41-strand, tinned copper, approved for switchgear use.
 - 2. All wire terminations made at terminal blocks, meters, relays and other similar devices, shall be made with cage type pressure terminals.
 - 3. All control wiring shall be protected with circuit breakers. The control system shall monitor all control power fusing and alarm when there is a circuit breaker trip.
 - 4. Each internal interconnecting wire shall be identified by means of a suitable permanent sleeve-marker at each end. Labeling tape wire markers are not acceptable. Wire numbers shall match the manufacturer's interconnection, schematic and wiring drawings.
 - 5. Terminal blocks shall utilize "Cage-Clamp" technology. Terminal blocks shall be supplied and clearly marked for wiring to be installed or reconnected by the Contractor. All connections between shipping sections shall utilize plug connections to reduce installation time. All terminal blocks shall provide a high clamping force, maintenance-free termination

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6. All current transformers shall be connected to shorting type terminal blocks. Current transformer secondary leads shall be #12 AWG. Terminations between the current transformers and the shorting type terminal blocks shall be made with ring type lugs or cage type pressure terminals.
7. All instruments shall be switchgear type, 4.5 inch square recessed case and 250 degree scale, 1% accuracy. Instrument control switches shall be heavy-duty rotary type, ElectroSwitch type 24 or equal.
8. All pilot lights shall be panel back-lit window type with lamp test switch. All Lights shall be LED type.

2.4 NAMEPLATES

- A Nameplates: Provide laminated black phenolic resin with white core with engraved lettered nameplates for each circuit breaker to indicate the feeder, panel-boards and equipment served; mounted with plated screws, adjacent to or on the front of the breaker. Refer to Nameplate Detail on the Drawings.

2.5 EQUIPMENT

- A Engine Generator Control Cubicles, (quantity of 2), each consisting of the following:
1. Each engine generator shall be furnished with the following basic components and any additional equipment necessary to provide for a complete and dependable system:

1	A.C. ammeter, scale as required, 5-ampere movement
1	4-position ammeter selector switch
1	A.C. wattmeter, scale as required
1	Synchroscope switch (key interlocked)
1	Frequency meter switch Bus-Off-Generator nameplates (key interlocked)
1	Circuit breaker control switch with circuit breaker status indication (CB open, CB closed, CB withdrawn)
1	Automatic synchronizer, Woodward type SPM-A, or as manufactured by the manufacturer of the engine governor controller
1	Reverse power relay, ABB or Basler type 32R or equal (anti-motoring), door-mounted in a draw-out case
1	Set of potential transformers, ratio as required
1	Set of current transformers, ratio as required
1	Set of main bus with full phase, neutral and separate ground bus. All bus to be silver-plated copper.
1	Interior fluorescent light fixture with door switch
1	Set of control wiring, fuses, fuse blocks, terminals, nameplates, etc. All wiring to be numbered at both ends.
1	Engine selector switch with Stop/Re-set-Off-Auto-Run nameplate

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1	Electrically operated, fixed type, low voltage power circuit breaker, with adjustable solid state over-current and short circuit trips, ground fault indication only with lock-out relay to prevent re-closing. Minimum interrupting rating shall be 65KAIC. Breaker to be of quick close (5 cycle) type. Circuit breaker shall be Eaton MPS type with trip units incorporating power metering or equal		
1	Set of NEMA mechanical type lugs for connection to generator source connection		
1	Mounting only of governor control box and speed setting potentiometer furnished by the engine generator manufacturer		
1	Coordination with engine mounted voltage regulator equipment furnished by the engine generator manufacturer		
1	Voltage adjust switch or potentiometer		
1	Distributive I/O rack, VersaMax, complete with input/output modules, communication modules, power supplies, etc., as required for starting and stopping controls for each engine generator.		
1	Modbus/Ethernet Gateway interface for reading engine alarms and status points.		
1	D.C.-to-D.C. converter to provide stable voltage to PLC		
1	Annunciator lamp test push-button (to test all lights)		
1	Back-lit annunciator panel with red indicators for shut-down failure and amber indicators for alarm conditions and green indicator for status conditions. The annunciator windows shall be engraved to indicate the nature of the alarm condition or failure. All alarms shall be of the "ring-back" type, i.e. any time the alarm horn is silenced for a failure, the next failure or alarm shall re-energize the alarm horn. The following fail circuitry and annunciation shall be provided:		
1	Engine Shutdown	Red	Shutdown
1	Engine Alarm	Amber	Alarm only
1	Breaker Failure	Red	Shutdown
1	Engine Not Available	Red	Shutdown
1	Engine Running	Green	Status
1	Control Voltage Failure	Red	Alarm
1	Spare		

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2. In addition to the above lights, additional engine alarms are shown via the operator interface panel. Additional alarms shall include: Approach Low Oil Pressure, Low Water Temperature, Approach High Water Temperature, Battery Charger Failure, Low Fuel Day Tank, High Fuel Day Tank, Day Tank Rupture, Remote Engine CB Open and Ground Fault Alarm. Additional shutdowns shown on the operator interface panel shall include: Over-speed, Over-crank, Reverse Power, Over-current, (circuit breaker trip & lock-out), Failure to Synchronize, Low Lube Oil Pressure, High Water Temperature and Emergency Stop.

1	Separate back-lit display with engraved windows and the following circuit breaker status indications:
	- Circuit breaker opened - Circuit breaker closed - Circuit breaker drawn out
1	Set of contacts for some summary alarm conditions for possible remote use

B Master Control Cubicle, (quantity of 1), consisting of the following:

1. The master control cubicle shall be furnished with the following basic components and any additional equipment necessary to provide for a complete and dependable system:

1	Metal enclosed cubicle
1	Lot of rail for CB lifting device (if required)
2	Independent and redundant programmable logic controllers, General Electric Series RX3i or equal, with communication modules, power supplies, etc., as required
1	Ethernet hub with a spare port for customer-use, utilizing MODBUS TCP/IP protocol
2	D.C.-to-D.C. converter to provide stable voltage to PLC
1	Solid state PLC Operator Interface Screen – 21.5" color touch-screen type
1	Manual paralleling permissive relay to prevent manual paralleling until both systems are within acceptable limits, Crompton Model 256
1	Voltmeter selector switch reading phase-to-phase
1	Main Bus Voltage/Frequency Failure relay with fail light and re-set pushbutton
1	Fail to synchronize time delay
1	Station alarm horn with silencer switch and light
1	Master Auto-Man switch with flashing red light to indicate when the switch is not in the "Auto" position
1	Back-lit annunciation panel with engraved nameplates for the following alarm conditions:
1	Main tank low fuel
1	Control not in automatic

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1	Critical control voltage failure
1	Alarm horn silenced
1	Start signal present
1	Load shed activated
1	Voltage/ Frequency failure
1	PLC1 in control
1	PLC2 in control
1	PLC failure
1	Operator interface alarm
1	lot of Spare(s)
1	Annunciator lamp test push-button (to test all lights)
1	In addition to the above lights, the OIP shall display other system status and alarm conditions including but not limited to the following: Control Voltage Failure, PLC Low Battery, Bus Over-voltage, Bus Under-voltage, Bus Over-frequency, Bus Under-frequency, Overload, Load Shed On, Main Tank Low Fuel Level, PLC I/O failure (identifies location and type of failure), Station Battery Alarm, station battery charger summary alarm and All Engine Pre-alarms and Alarms
1	Interior fluorescent light fixture with door switch
1	120A.C. convenience, duplex receptacle, wired out for control power supplied from an external source
1	Provide a terminal strip with system alarm signals wired out for remote annunciation
1	Synchronizing swing panel (mounted on Master Cubicle door) including:
1	Kilowatt meter, scale as required, to read full load of generator sets
1	Bus A.C. voltmeter, scale as required, reading phase-to-phase
1	Synchroscope
2	Synchronizing lamps
1	Frequency meter for station bus & generator units, dial type, 55-65 hertz scale
1	Set of main bus with full phase, neutral and separate ground bus. All bus to be silver-plated copper.
1	Set
1	Solid state best battery selector system
1	Set of control wiring, fuses, fuse blocks, terminals, nameplates, etc. All wiring to be numbered at both ends.
1	Set of mechanical lugs for temp Gen / load bank connection.

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1	Provide form "C" dry contact that will operate upon receipt of any ATS start signal. This will be used for possible load bank dump signal or temp generator start signal.

C Distribution Cubicles, consisting of the following:

1. Each distribution cubicle with circuit breaker(s) as shown on the drawings shall be an integral part of the generator control switchboard and manufactured by same for singularity of responsibility and continuity of design. The distribution cubicles shall match and line up with the generator control switchboard and each shall consist of the following equipment as specified and as shown on the drawings:

1	Set of 3 phase, emergency bus with full neutral and separate ground bus. All bus shall be silver-plated copper.
1	Lot of rail for CB lifting device
1	Lot of CB as shown on drawing. Circuit breakers shall be manually-Operated, fixed power circuit breakers with adjustable long, short, long time, short time and instantaneous trips. Minimum interrupting rating shall be 65KAIC. Circuit breakers shall be Eaton Magnum MPS with trip units or equal
1	Set of control wiring, fuses, fuse blocks, terminals, nameplates, etc. All wiring to be numbered at both ends.
1	Lot of Mechanical type lugs

2.6 EQUIPMENT AND COMPONENTS

A Automatic Starting System

1. The automatic starting system shall be controlled by a network interface unit, Versa Max, complete with analog, digital, input/output module, etc. as required for each engine generator.
2. A network interface unit shall be furnished in each engine control cubicle and will provide serial interface to the two (2) system PLCs located in the Master cubicle. Programming shall be the responsibility of the generator control switchgear manufacturer.
3. Programmable timer access shall be provided within the operator interface, for each engine generator, to allow for the fail to synchronize (30 to 360 seconds), and cool-down time (0 to 600 seconds), Hand-held PLC programmers and/or laptop computers to make timer settings are not acceptable.
4. A fail to synchronize time delay operation shall be provided for each generator to terminate the operation of the synchronizer and sound a warning horn, in the event the generator is unable to be synchronized within an adjustable period of time. After failing to synchronize automatically, the operator, at his discretion, shall be able to connect either one or all the engine generators to the emergency bus by turning the master control switch, located in the master control cubicle, to the manual position, and by operating the manual synchroscope system and the circuit breaker control switches.
5. Each PLC shall be provided with a separate power supply for input power to prevent over-voltage conditions and to maintain sufficient control power to the PLC during engine cranking.

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6. Required Operation of the Fail Light, Lock-out and Alarm System: Each engine generator unit shall be provided with fail lights to shut down an engine generator, disconnect it from the main bus and illuminate a light to indicate the nature of the failure. If the generating plant is running automatically with the master selector switch in the "Auto" position, the fail light shall illuminate and the engine generator shall be locked out. To re-set an engine generator after a failure while in automatic operation, the engine selector switch shall be rotated to the "Stop/Reset" position.
 7. Provide a two-position "Automatic/Manual" selector switch in the emergency generator control switchgear to permit operating and testing as follows:
 - a. In the "Automatic" position, all functions shall perform in the sequence as specified hereinafter.
 - b. In the "Manual" position, all automatic functions shall be locked out and the opening and closing of breakers, synchronizing and paralleling procedures may be manually performed.
 8. Four-position "Stop/Reset-Off-Auto-Run" in each Engine Generator Control Panel.
 - a. When the selector switch is in the "Stop/Reset" position, the generating plant shall be locked out. Whenever the selector switch is placed in the "Stop/Reset" position while the engine generator is operating, it shall immediately shut down and its circuit breaker shall trip.
 - b. An "Off" position shall be provided to allow a normal shut-down with a time delay to allow the engine to cool after operating under load. Whenever the engine selector switch is placed in the "Off" position while the engine is operating, the generator circuit breaker shall trip, but the engine shall continue to operate until the expiration of cool-down time delay.
 - c. When the engine selector switch is placed in the "Auto" position, the engine generator shall be on standby and shall start whenever a power failure signal is given from the automatic transfer system. When the commercial power returns and the transfer system signals the engine generator to shut down, the circuit breaker shall be tripped and the engine shall continue to operate for the cool-down time delay period before shutting down in readiness for the next power failure.
 - d. When the engine selector switch is placed in the "Run" position, the engine shall start and come up to speed. It shall continue to run until the selector switch is returned to "Auto", "Off" or "Stop" position. This position shall be used for testing or for manual operation.
 9. Coordinate the functions and circuitry of the various selector switches to insure that the various settings available do not cause malfunction in the intended system operation.
- B Reverse Power Relay:
1. The door-mounted reverse power relay shall protect the prime mover and generator against motorization. A reverse power relay, upon sensing a motorizing condition on any plant, shall disconnect and shut-down of the failing plant and shall contain the following features and capabilities:
 - a. A self-contained single phase, solid state type reverse power relay, one for each generator, shall be furnished to detect excessive reverse power flow caused by the motorizing of a failing generator plant. The reverse power relay shall have inverse time current characteristics to prevent needless shutdown during periods of light loading. Upon detection of a true reverse power flow, the relay shall include the following features:

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- 1) Time Delay - An adjustable time dial shall be provided with inverse time characteristics
 - 2) Sensitivity - Adjustable from 13 to 150 watts
 - 3) Output Relay Contacts - Single pole, normally open contacts rated to close 30 amperes to 250 VDC.
 - b. The relay shall be utility-grade, supplied with a draw-out case. The removable chassis shall permit rapid interchanging of similar relay units without requiring panel wiring changes. Chassis units shall be easily removable for test and inspection purposes. Current transformer secondaries shall be automatically short circuited when the relay chassis is removed from the case. The draw-out case shall have a dust-tight removable cover.
 - c. Reverse power monitors not having inverse time characteristics are not acceptable.
- C Automatic Synchronizer:
1. An automatic synchronizer shall be provided, one for each engine, with the following features and capabilities:
 2. All circuitry shall be housed in a rugged semi-dust-tight enclosure suitable for panel mounting. The synchronizer shall contain all control adjustments and input/output terminals legibly marked. The inputs shall consist of 120 volt A.C. nominal, 60 Hz, signals from the selected power sources. A separate terminal shall be provided to ground the enclosure.
 3. The outputs shall consist of the following:
 - a. A bi-polar D.C. signal suitable for driving a governor/amplifier system.
 - b. A sync contact closure, the purpose of which shall be to operate the selected power circuit breaker when the incoming voltage has the same amplitude, frequency and phase as the main switchboard bus.
 - c. The synchronizer shall become operative when the incoming voltage source reaches approximately 75% of nominal. It shall assume control to match the frequency and phase of the engine generator with that of the main switchboard bus rapidly, and close the selected power circuit breaker with a minimum of system disturbance. Power circuit breaker closures outside the pre-set limits shall not occur.
 4. Within approximately 1 second after the power circuit breaker closure, the synchronizer shall automatically relinquish control over the electronic governor and go into an idle mode.
 5. The synchronizer controls shall consist of the following:
 - a. Phase Off-set Control
 - b. Gain Control
 - c. Stability Control
 6. The synchronizer shall operate over an input voltage range of 80% to 125% of nominal indefinitely and over an ambient temperature range of -45C to +70C. The synchronizer shall be capable of meeting the dielectric and surge withstand capabilities as set forth in IEEE standard 472-1974/ANSI C37.
- D Synchroscope & Synchroscope Switches
1. Switchboard instrument with 4.5-inch (115 mm) square recessed case and 360-degree scale, white dial with black figures, 60 Hertz, one percent accuracy, 150v movement.
Scale: Slow – Fast

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2. Synchroscope Switches: Each synchronizing breaker is provided with a keyed synchroscope switch that energizes the synchroscope, sync lights and the manual sync check relay. This relay will prevent breaker closure unless the two sources are within acceptable limits of synchronism. An interlock shall insure that these breakers have their sync switches on before closure is allowed. These switches have separate keyed handle (different from the frequency switches) that are removable in the "Off" position only, assuring that only one respective switch is on at any time. Only one keyed handle is provided.
- E Manual Paralleling Permissive Relay:
1. A manual paralleling permissive relay (sync check relay), Crompton Model 256, shall be provided to activate the circuit breaker closing circuit when adding sources to the bus. It shall compare the phase angle of the voltage of the oncoming source to the bus voltage. When the phase angle of the two voltages is within the acceptable phase band window, the output relay contacts shall close to activate the circuit breaker closing circuit. In addition, a special lock-out circuit shall be provided to prevent output relay contact closure if, upon energization, the first condition the relay sees is an in-sync condition. This shall prevent closure of the output relay as the two voltages are moving away from the sync condition. This shall insure that the output relay shall energize only when the two voltages are decreasing in phase angle difference.
- F System Programmable Controller:
1. The system shall be controlled by redundant programmable controllers (PLCs) with separate power supply, chassis and input/output cards. In the event of a controller failure, automatic operation of the system shall be carried out by the second PLC with no loss of functionality. All PLC programming shall be the responsibility of the switchgear manufacturer.
- G Master Cubicle Operator Interface Panel: Master Operator Interface Panel:
1. A 21.5 color touch-screen operator interface panel shall be supplied. The master operator interface panel shall communicate with the master control PLC and provide operator access to set points, engine sequence system alarms, switchgear system one-line and various switchgear functions. Any of the set points and the engine sequence will be viewed at any time, but changes shall be password protected to prevent tampering. Each set point shall have pre-programmed high and low limits to ensure that a chosen value is within an acceptable range.
 - a. Password Screen: On this screen, the operator must enter a password to change control set points. The system contains up to eight levels of password protection.
 - b. Date and Time Screen: The Date and Time screen will allow an operator to change the system's date and time. The operator will enter a password and then access the Date/Time screen by pressing the key.
 - c. Main Menu Screen: This screen will index all the pages used in the system.
 - d. Generator Breaker Status Screen: The generator breaker status screen will display actual generator power in kW, rated kW and circuit breaker open/closed status for each generator in the system.

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- e. Engine Sequence Screen: The Engine Sequence screen will display the engine sequence, locked out or future for each engine in the system. The operator will program the engine sequence at any time through this screen to change the starting and stopping sequence of the engines for load demand operation.
- f. Generator Demand Set Points Screen: The generator demand set points screen will display the generator demand timer, decrease set point, decrease timer, increase set point and increase timer.
- g. Load Control Set Points Screen: The load control set points screen will display the under frequency load shed timer set point, over-load kW set point, over-load timer set point, auto/man load control, current load step and load shed activated.
- h. ATS Load Test and Load Control Priority Screens: These screens will allow the operator to define the set priorities of at least 32 transfer switches. These screens display the start signal, priority assignment, anticipated load value, load add, load shed, auto/man load control, current load step and load shed activated for each ATS in the system. This screen shall provide the ability to initiate a load test signal to selected transfer switches. Screen shall allow the operator to select "load test enable/disabled" for each transfer switch. A single touch-screen function button will initiate a load test signal to the selected transfer switches. The position of each transfer switch (normal or emergency) shall be displayed on the touch-screen.
- i. Active Alarm and Event List Screens: Upon receipt of an alarm, the touch-screen will automatically display the active alarm screen. A red operator interface alarm indicator on the Master control panel door will also illuminate, and the alarm horn sounds. All alarms can be acknowledged on the touch-screen. The event list screen will provide a system and alarm time/date history.
- j. System One-Line Screen: The system one-line screen will allow the operator to view the current status of the synchronizing switchgear. All generator and circuit breakers shall be displayed with a color keyed to indicate status (engine running, engine locked out, bus energized, CB closed, CB open or CB racked out). This screen shall include pop-up windows displaying the power metering information from the 5.0P trip units for all generator CBs and load distribution CBs and ATS metering.
- k. Control Functions: The operator interface panel touch-screen or control function keys will enable certain master control functions. The operator interface panel function keys will be assigned as follows:
 - 1) Generator Demand (On/Off Switch Function): The function key will allow operating personnel to enable or disable the generator demand operation
 - 2) System No-Load Test (On/Off Switch Function): The function key will be provided to permit supervised testing of the system. When the function key is enabled, the system automatically starts all standby engine-generator sets, synchronize them and close their breakers to the bus, but the automatic transfer switches will remain connected to the normal supply. When the function key is disabled, the system shall initiate the shutdown of the engine generators and restore all equipment to normal operation.

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- 3) Auto Load Control (On/Off Switch Function): The function key will provide for load control operation. If the LED for the function key is off, the over-load shed control operation is defeated and the system will allow supervised loading of the engines up to their maximum rating. Should an under-frequency condition occur, the load shed bypass shall be defeated and load shedding shall occur as previously described.
 - 4) Load Add (Pushbutton Function): Supervised loading of the engines up to their maximum rating using the add non-essential loads function button. Each priority load may be programmed for smaller steps. And each time this button is pressed, the next priority step of load is added. If an under frequency condition occurs, the bypass is defeated and load shedding occurs.
 - 5) Load Shed (Pushbutton Function): The shed load pushbutton on the operator interface panel shall allow immediate load shed of the next lowest priority non-essential load. Each time the pushbutton is depressed the next priority load shall be shed. Priority 1 loads shall not be shed and shall be within the rating of a single generator. This pushbutton shall remain functional in both manual and automatic operation; however, in the automatic mode, any shed load shall be re-added once the button is released, provided the bus is capable of increased load.
 - 6) Increase Load Capacity (Pushbutton Function): This pushbutton allows an operator to immediately place the next engine-generator in sequence on line.
- H At the Operator interface Panel, provide a password protected, one-button, monthly testing capability. This soft button operation will start and parallel all generators to the bus and transfer all selected ATSs. Three types of reports will be generated: Engine data, ATS data and an Alarm & Event log. The reports will be in PDF format, stored locally, and easily copied to USB drive or down-loaded direct to a printer via USB port on the system control cubicle door.
1. Engine Data will include:
 - a. Date/Time-stamp of each gen-set run period
 - b. Graphical trend of kW, kVA, and kVAR
 - c. Graphical trend of volts, amps, RPM and frequency
 - d. Graphical trend of coolant temp, oil pressure, battery pressure and exhaust temp
 2. ATS DATA will include:
 - a. Start signal, normal position on/off and emergency position on/off
 - b. Proof of 10 sec transfer for those required
 3. Alarm and Event Log will include:
 - a. All alarms and events captured during recording period
 - b. Encompass all Genset, ATS, circuit breaker and switchgear activity
- I The Master Control PLC's and Operator Interface Touchscreen (OIP) shall be provided with a separate SIMULATOR PROGRAM. This program shall be activated on the Touch Screen as a simulator mode of operation. This program will allow the operators to simulate operation and end users can be trained on the automatic operation of the switchgear and OIP. All set points and controls that are on the OIP are active while in the simulator mode. All set points and controls that are outside of the OIP are accessible via simulation windows.

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1. When the simulator mode is activated, users can safely operate the switchgear in a simulated environment and set point changes, such as time delays or priority assignments can be tested on the simulator before being set in an on line system. This Program shall be password protected and alarmed to indicate the system is in the simulator mode of operation. If any PLC related alarm occurs or if a new engine start signal is received in the actual switchgear being monitored and or controlled by the PLC, the simulator mode of operation will immediately be cancelled.
- J Alarm Horn: A station alarm horn and silencing circuit with indicating lamp shall be provided to sound an audible should a malfunction occur. Should the alarm be silenced after a malfunction, receipt of another signal shall cause the horn to sound again (Annunciator Ring Back). When the failed circuit has been corrected the alarm horn shall be automatically re-set. Horn shall be rated for 88 to 90 decibels at 10 feet.
- K Master Control Relay System: The master control relay system shall utilize heavy-duty, industrial grade control relays. All synchronizing circuit relays shall embody the fail-safe principle with dual contacts in parallel in transparent enclosures.
- L Back-lit LED Annunciation Panel: The annunciator shall have individual 1.575" x 1.575" square translucent windows with black engraved 3/8" lettering to indicate the nature of the alarm condition or failure. LED indicators shall be plug-in type with dual circuit design incorporating four redundant strings of LEDs such that a failed LED string does not render the lamp inoperative.
- M Master cubicle shall be equipped with all necessary hardware (terminal strips, PLC I/O, etc...) to interface with eventually a quantity of (8) eight automatic transfer switches.

2.7 MANUFACTURED UNITS

- A Description: Factory assembled and tested and complying with IEEE C37.20.1 and UL 1558.
- B Ratings: Suitable for application in 3-phase, 60-Hz, solidly grounded neutral system.
- C Indoor Enclosure Material: Steel.
- D Access: Fabricate enclosure. No rear access.
- E The last generator control cubicle and distribution cubicle shall have bus sized and drilled for extension into future cubicles.
- F Phase-, Neutral-, and Ground-Bus Materials: Extend full length of switchgear.
 1. Phase and Neutral Bus: Copper, silver plated at connection points.
 2. Ground Bus: Copper, silver, tin plated; minimum size 1/4 by 2 inches (6 by 50 mm).

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- G Switchgear Components: Incorporate components as indicated on Drawings.
1. Instrument Transformers: Comply with IEEE C57.13.
 - a. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - b. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.
 2. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems, listed and labeled by UL, and with the following features:
 - a. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 - b. Switch-selectable digital display with the following features:
 - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
 - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - 4) Three-Phase Real Power: Plus or minus 2 percent.
 - 5) Three-Phase Reactive Power: Plus or minus 2 percent.
 - 6) Power Factor: Plus or minus 2 percent.
 - 7) Frequency: Plus or minus 0.5 percent.
 - 8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - 9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - 10) Backnet compatible for connection to BMS system.
 - c. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.
 3. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.
 4. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices. Include the following features:
 - a. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
 - b. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.
 5. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
 - a. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
- H Identification: Electrical identification devices and installation requirements are specified in Section 260553 "Identification for Electrical Systems."
1. Identify units, devices, controls, and wiring.

2.8 CIRCUIT-BREAKER SWITCHBOARD (1000 V AND LESS)

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- A Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified: manufacturer selected shall match that of other electrical equipment specified for the project
1. Cutler-Hammer; Eaton Corporation.
 2. General Electric Company.
 3. Square D; Schneider Electric.
 4. Eaton Corporation
- B Description: Factory assembled and tested, and complying with IEEE C37.20.1 and UL 891.
- C Nominal System Voltage: 480/277 V, 4 wire, 60 Hz.
- D Main-Bus Continuous: 3000 A.
- E Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.
- F Switchboard Fabrication:
1. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
 2. Circuit-breaker compartments shall be equipped to house fixed power circuit breakers Eaton MPS style and shall be fitted with hinged outer doors.
 3. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
 - a. Bus transition sections.
 - b. Pull sections.
 - c. Hinged front panels for access to accessory and blank compartments.
 4. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.
 - a. Main Phase Bus: Uniform capacity the entire length of assembly.
 - b. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing neutral conductors.
 - c. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
 - d. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
 - e. Neutral Disconnect Link: Bolted, un-insulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
 - f. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
 - g. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
 - 1) Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
 - 2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

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5. Circuit-Breaker Terminals for Cable Connections: Silver-plated copper bus extensions equipped with pressure connectors for conductors.
- G Circuit Breakers: Comply with IEEE C37.13 and UL 489.
1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
 2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 - a. Normal Closing Speed: Independent of both control and operator.
 - b. Slow Closing Speed: Optional with operator for inspection and adjustment.
 - c. Stored-Energy Mechanism: Manually charged.
 - d. Operation counter.
 3. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
 - a. Eaton PXR25 or equal by General Electric or Square D.
 - b. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment
 - c. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
 - d. Field-adjustable, time-current characteristics.
 - e. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
 - f. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
 - g. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I2t operation.
 - h. Pickup Points: Five minimum, for instantaneous-trip functions.
 - i. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
 - 1) Four-wire circuit or system.
 - 2) Four-wire, double-ended substation.
 - j. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
 - k. Maintenance mode switched trip units: The trip unit shall utilize Arc Flash Reduction Maintenance System to reduce the instantaneous pickup value when activated. The ARMS shall provide a clearing time of 0.04 seconds with a minimum of settings from 2.5X to 10X of the sensor value. The ARMS shall be enabled by a switch on the trip unit with blue indicator LED. A remote communication link shall also be provided for enable/disable and confirmation.
 4. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two type "a" and two type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

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5. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
 - a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.
 - b. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed, unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
 - 1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
 - 2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
 6. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position; arranged to permit inspection of contacts without removing circuit breaker from switchgear.
 7. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
 8. Operating Handle: One for each circuit breaker capable of manual operation.
 9. Electric Close Button: One for each electrically operated circuit breaker.
 10. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
 11. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
 12. Undervoltage Trip Devices: Where indicated, adjustable time-delay and pickup voltage.
 13. Shunt-Trip Devices: Where indicated.
 14. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.
 15. Lugs: Mechanical style, rated for Copper conductors only, suitable for number, size, and trip ratings.
 16. Grounding Ball Studs: provide on incoming lug pad and outgoing lug pad.
 17. Provide shorting blocks for maintenance.
- H Accessories: Furnish tools and miscellaneous items required for circuit-breaker and switchgear tests, inspections, maintenance, and operation.
1. Racking handle to manually move circuit breaker between connected and disconnected positions.
 2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
 3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
- I Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.

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- J Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.
- K Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections to accept Circuit Breaker without field changes.

2.9 NETWORK COMMUNICATIONS

- A Connect remote monitoring communication modules to Owner's data network through appropriate network interface unit.
- B The manufacturer shall wire between all communications capable devices within the switchgear, including electronic meters with the same protocol and wire to a set of easily accessible terminal blocks.

2.10 IDENTIFICATION

- A System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
 - 1. Frame size of each circuit breaker.
 - 2. Trip rating for each circuit breaker.
 - 3. Conduit and wire size for each feeder.

PART 3 EXECUTION

3.1 INSTALLATION

- A Comply with applicable portions in NECA 400.
- B Install switchgear assembly on a concrete base. Anchor according to manufacturer's written instructions.
 - 1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems" and Division 3 Concrete Sections

3.2 CONNECTIONS

- A Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

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- B Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables.
- C Verify tightness and torque all accessible bolted electrical connections to manufacturer's specified values using a calibrated torque wrench. Provide a list of all torqued connections and values.
- D Provide all communications wiring between remote monitoring communication modules and the Owner's data network.

3.3 GENERATOR SUPERVISION REQUIREMENTS

- A Provide a generator remote annunciator panel and a generator manual start and transfer panel in Fire Command Center on the first floor.

3.4 IDENTIFICATION

- A Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."
- B Diagram and Instructions:
 - 1. Frame and mount under clear acrylic plastic on the front of switchgear.
 - a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
 - b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
 - 2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.5 FIELD QUALITY CONTROL

- A Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B The switchgear manufacturer shall provide a minimum of four trips by a qualified factory technician: One prior to installation for coordination with electrical contractor; one after installation by others for check-out and start-up; one trip for final testing and Owner instructions and one approximately six months after installation for final system operating instructions.
- C Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

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1. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
 2. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in other electrical Sections.
 3. Complete installation and startup checks according to manufacturer's written instructions.
 4. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
 5. Report results in writing.
- D Perform the following field tests and inspections and prepare test reports:
1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
 - a. Switchgear.
 - b. Circuit breakers.
 - c. Protective relays.
 - d. Instrument transformers.
 - e. Metering and instrumentation.
 - f. Ground-fault systems.
 - g. Battery systems.
 - h. Surge arresters.
 2. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

- A Set field-adjustable, protective-relay trip characteristics according to results in Section 260573 "Electrical System Studies."

3.7 DEMONSTRATION AND TRAINING

- A Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.
- B The instructions shall be presented in an eight-hour session. The Field Service engineer will provide instructions on the operation and maintenance of the switchgear, circuit breaker, protective relays and PLC equipment.
- C Provide both classroom training and hands-on equipment operation.
- D Schedule training with the Owner through the Architect/Engineer with at least seven working days advance notice.
- E The training session(s) shall be recorded.

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END OF SECTION 262313

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SECTION 262413
SWITCHBOARDS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes:
1. Switchboards rated 600 V and less.
 2. Surge suppression devices.
 3. Disconnecting and overcurrent protective devices.
 4. Instrumentation.
 5. Control power.
 6. Accessory components and features.
 7. Identification.
- B Related Sections include the following:
1. Division 26 Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits" for transient voltage surge suppressors for low-voltage power, control, and communication equipment located in the switchgear.
 2. Division 26 Section 260573 "Electrical System Studies" for short-circuit rating of devices and for setting of overcurrent protective devices.

1.3 ACTION SUBMITTALS

- A Product Data: For each type of switchboard, overcurrent protective device, surge suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B Shop Drawings: For each switchboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Detailed short-circuits current rating of switchboards and overcurrent protective devices.

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5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
8. Include schematic and wiring diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition include the following:
1. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Indicating Lights: One of each size and type.

1.7 QUALITY ASSURANCE

- A Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

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- B Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by UL and marked for intended location and application.
- D Use of series rated equipment is prohibited.
- E Comply with NEMA PB 2.
- F Comply with NFPA 70.
- G Comply with UL 891.
- H Comply with Owner Design Standards.

1.8 DELIVERY, STORAGE, AND HANDLING

- A Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B Remove loose packing and flammable materials from inside switchboards.
- C Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 PROJECT CONDITIONS

- A Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B Environmental Limitations:
 - 1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

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- C Service Conditions: NEMA PB 2, usual service conditions, as follows:
1. Ambient temperatures within limits specified.
 2. Altitude not exceeding 6600 feet (2000 m).

1.10 COORDINATION

- A Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 WARRANTY

- A Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

- A Provide products by one of the following:
1. Eaton Corp. Electrical Group
 2. Schneider Electric; Square D
 3. Siemens
- B Basis of Design: Switchboards shown on Drawings are based on equipment by the underlined manufacturer listed first above.
1. Other approved manufacturers, including those approved by substitution requests prior to bid award, are allowed on condition that the contractor provides accessories and added labor as needed to meet requirements of Contract Documents at no added cost to owner.
 2. Equipment ordered, shipped, and/or installed (a) using a manufacturer not approved prior to award of bid, or (b) without owner-approved shop drawings, or (c) without owner-approved power system studies per Specification Section 26 05 73 is subject to replacement at no cost to owner.

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3. In addition, Contractor is responsible for supplying equipment that fits in the available space as shown on Contract Documents, including code and manufacturer required working and service clearances around the equipment as well as clearance and pathways for future removal and replacement of equipment as shown on Drawings.
- C Front-Connected, Front-and-Rear Accessible Switchboards:
1. Main Devices: Fixed, individually mounted.
 2. Branch Devices: Panel mounted.
 3. Sections front and rear aligned.
- D Nominal System Voltage: 480Y/277 V.
- E Main-Bus Continuous: As scheduled.
- F Factory certified 3 cycle rating.
- G Indoor Enclosures: Steel, NEMA 250, Type 1.
- H Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- I Barriers: Between adjacent switchboard sections.
- J Insulation for main bus of main section and main of feeder sections.
- K Customer Metering Compartment: Where indicated, a separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.
- L Transition and Incoming Sections: Matched and aligned with basic switchboard.
- M Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- N Buses and Connections: Three-phase, four-wire unless otherwise indicated.
1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated, with tin-plated aluminum or copper feeder circuit-breaker line connections.

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2. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 3. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 4. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 5. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 6. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- O Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 TRANSIENT VOLTAGE SUPPRESSION DEVICES

- A Surge Protection Device Description: IEEE C62.41-compliant externally mounted, UL 1449 3rd edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:
1. Comply with Division 26 Section "Surge Protective Devices".
 2. Provide a dedicated three pole circuit breaker for the SPD in the switchboard.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A Molded-Case Circuit Breaker (MCCB) Up To 1200 A: Comply with UL 489, 100% rated to meet available fault currents. Use of series rated equipment is prohibited.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
 - a. Fixed instantaneous setting for circuit-breakers up to but not including 100 A.
 - b. Adjustable instantaneous setting (up to ten times rated current) for circuit-breakers 100 A and up to but not including 225 A.
 2. Electronic trip circuit breakers, 225 A and larger shall have RMS sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 3. Circuit breakers 800 A and larger shall be 100% rated for their input current.
 4. Circuit breakers shall be equipped with back-up thermal and magnetic trip system.
 5. Molded-Case Circuit-Breaker (MCCB) Features and Options:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, dual rated CU/AL, suitable for number, size, and trip ratings.

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- c. Ground-Fault Protection: For devices greater than or equal to 1000 amps and at least 150 volts to ground, the trip unit shall utilize Ground-Fault Protection. Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- d. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage. Provide for source breakers for Closed Transition Transfer Switches.
- e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
- f. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
- g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- h. Maintenance mode switched trip units: For frames that can accept a 1200 amp trip unit, the trip unit shall utilize Arc Flash Reduction Maintenance System to reduce the instantaneous pickup value when activated. The ARMS shall provide a clearing time of 0.04 seconds with a minimum of settings from 2.5X to 10X of the sensor value. A 30 mm selector switch labeled Maintenance Mode and Normal shall enable the ARMS feature of the trip unit. When in the maintenance mode a blue 30mm LED Pilot light labeled maintenance mode shall be illuminated. A remote communication link shall also be provided for enable/disable and confirmation.

2.4 CIRCUIT BREAKERS – MAIN DEVICES, DISTRIBUTION DEVICES, AND TIE DEVICES
GREATER THAN OR EQUAL TO 1600A

- A Description: Comply with IEEE C37.13 AND UL 1066.
 - 1. Eaton Magnum PD-SB or equal by or Square D or Siemens, Insulated case type power circuit breaker.
- B Ratings: As indicated, fully rated, for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
 - 1. Minimum frame size shall be 1600 A.
- C Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
 - 1. Normal Closing Speed: Independent of both control and operator.
 - 2. Stored-Energy Mechanism: electrically charged.
 - 3. Operation counter.
- D Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
 - 1. Eaton Digi-Trip 1150 plus or equal by Square D (Micrologic) or Siemens.
 - 2. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
 - 3. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
 - 4. Field-adjustable, time-current characteristics.

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5. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
 6. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
 7. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I_{2t} operation.
 8. Pickup Points: Five minimum, for instantaneous-trip functions.
 9. Ground-fault protection
 - a. For devices greater than or equal to 1000 amps and at least 150 volts to ground, the trip unit shall utilize Ground-Fault Protection. Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - b. With at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
 - 1) Three-wire circuit or system.
 - 2) Four-wire circuit or system.
 10. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
 11. Maintenance mode switched trip units: The trip unit shall utilize Arc Flash Reduction Maintenance System to reduce the instantaneous pickup value when activated. The ARMS shall provide a clearing time of 0.04 seconds with a minimum of settings from 2.5X to 10X of the sensor value. A 30 mm selector switch labeled Maintenance Mode and Normal shall enable the ARMS feature of the trip unit. When in the maintenance mode a blue 30mm LED Pilot light labeled maintenance mode shall be illuminated. A remote communication link shall also be provided for enable/disable and confirmation.
- E Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two-type "a" and two-type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.
- F Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
- G Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism. Provisions shall be included for padlocking the breaker in the open or closed position.
- H Operating Handle: One for each circuit breaker capable of manual operation.
- I Electric Close Button: One for each electrically operated circuit breaker.
- J Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

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- K Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
- L Single phasing protection: phase failure relay.
- M Undervoltage Trip Devices: Where indicated, adjustable time-delay and pickup voltage.
- N Shunt-Trip Devices: Provide on feeder source breakers for Closed Transition Transfer Switches and where indicated.
- O Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.
- P Lugs: Mechanical style, rated for Copper conductors only, suitable for number, size, and trip ratings.
- Q Grounding Ball Studs: provide on incoming lug pad and outgoing lug pad.
- R Provide shorting blocks for maintenance.

2.5 TIE BREAKER CONTROL

- A Key Interlocks arranged so keys are attached at devices indicated and requires one main circuit breaker in a double-ended unit substation to be open before the tie circuit breaker can be closed. Mountings and hardware are included where future installation of key-interlock devices is indicated.
- B All provisions necessary for automatic transfer control equipment to transfer a load bus from its normal source of supply to an alternate source using transfer scheme logic executed by a Programmable Logic Controller (PLC).

2.6 INSTRUMENTATION

- A Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
 - 1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 - 2. Current Transformers: IEEE C57.13; 5 Amp, 60 Hz, secondary and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

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3. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for four-wire systems and with the following features:
 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Megavars: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
 2. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door.

2.7 NETWORK COMMUNICATIONS

- A Connect remote monitoring communication modules through appropriate network interface unit to the Building Automation System.
- B The manufacturer shall wire between all communications capable devices within the switchboard, including electronic meters with the same protocol and wire to a set of easily accessible terminal blocks.

2.8 CONTROL POWER

- A Control Circuits: 120-VAC, supplied through secondary disconnecting devices from CPT (control-power transformer).
- B Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

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2.9 ACCESSORY COMPONENTS AND FEATURES

- A Furnish switchboard with all provisions necessary for future extension of buswork and enclosure, including terminal blocks in the tie breaker compartment for extension of the Ground Fault Protection scheme, to convert unit substation to double ended configuration.
- B Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- C Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- D Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.

2.10 IDENTIFICATION

- A Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
- B Presentation Media: Painted graphics in color contrasting with background color to represent bus and components complete with lettered designations.
- C Service Equipment Label: UL labeled for use as service equipment where required.

PART 3 EXECUTION

3.1 EXAMINATION

- A Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
- B Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D Proceed with installation only after unsatisfactory conditions have been corrected.

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3.2 INSTALLATION

- A Install switchboards and accessories according to NEMA PB 2.1.
- B Equipment Mounting: Install switchboards on concrete bases, 4-inch (100-mm) nominal thickness. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchboards unless otherwise indicated. Comply with requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems" and Division 03 Concrete Sections.
 - 1. Install dowel rods to connect concrete base to concrete floor on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor, install to elevations required for proper attachment to switchboards
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- C Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E Install filler plates in unused spaces of panel-mounted sections.
- F Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
- G Verify tightness and torque all accessible bolted electrical connections to manufacturer's specified values using a calibrated torque wrench.
- H Comply with NECA 1.

3.3 IDENTIFICATION

- A Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

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- B Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- C Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B Acceptance Testing Preparation:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - b. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D Switchboard will be considered defective if it does not pass tests and inspections.
- E Prepare test and inspection report, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

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- A Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Electrical System Studies."

3.6 DEMONSTRATION

- A Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION 262413

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SECTION 262416
PANELBOARDS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Electronic-grade panelboards.
 - 4. Intelligent panelboards.
- B Related Sections include the following:
 - 1. Division 26 Section "Surge Protective Devices for Low-Voltage Electrical Power Circuits" for transient voltage surge suppressors for low-voltage power, control, and communication equipment located in the switchgear.
 - 2. Division 26 Section "Electrical System Studies" for short-circuit rating of devices and for setting of overcurrent protective devices.

1.3 DEFINITIONS

- A SVR: Suppressed voltage rating.
- B SPD: Surge Protective Device.

1.4 PERFORMANCE REQUIREMENTS

- 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

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- A Product Data: For each type of panelboard, switching and overcurrent protective device, surge suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 6. Include wiring diagrams for power, signal, and control wiring.
 - 7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

1.6 INFORMATIONAL SUBMITTALS

- A Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.7 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

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2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Keys: Two spares for each type of panelboard cabinet lock.
 2. All panelboards shall be keyed alike

1.9 QUALITY ASSURANCE

- A Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D Comply with NEMA PB 1.
- E Comply with NFPA 70.
- F Series rated equipment shall not be used.
- G Use of "Load-center" type equipment is not acceptable.

1.10 DELIVERY, STORAGE, AND HANDLING

- A Remove loose packing and flammable materials from inside panelboards.
- B Handle and prepare panelboards for installation according to NEMA PB 1.

1.11 PROJECT CONDITIONS

- A Environmental Limitations:

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1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 22 deg F (minus 30 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

- B Service Conditions: NEMA PB 1, usual service conditions, as follows:
1. Ambient temperatures within limits specified.
 2. Altitude not exceeding 6600 feet (2000 m).

1.12 COORDINATION

- A Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.13 WARRANTY

- A Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A Basis-of-Design Products: Subject to compliance with requirements, provide products by
1. Eaton Corp. Electrical Group
 2. Square D; a brand of Schneider Electric.
 3. Siemens

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- B Basis of Design: Panelboards shown on Drawings are based on equipment by the underlined manufacturer listed first above.
1. Other approved manufacturers, including those approved by substitution requests prior to bid award, are allowed on condition that the contractor provides accessories and added labor as needed to meet requirements of Contract Documents at no added cost to owner.
 2. Equipment ordered, shipped, and/or installed (a) using a manufacturer not approved prior to award of bid, and/or (b) without owner-approved shop drawings, and/or (c) without owner-approved power system studies per Specification Section 26 05 73 is subject to replacement at no cost to owner.
 3. In addition, Contractor is responsible for supplying equipment that fits in the available space as shown on Contract Documents, including code and manufacturer required working and service clearances around the equipment as well as clearance and pathways for future removal and replacement of equipment as shown on Drawings.
- C Enclosures: Flush and surface-mounted cabinets.
1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Kitchen, Food Service and Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
 - d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 3. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 4. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pre-treating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
 5. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- D Incoming Mains Location: Top or bottom.
- E Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 4. Fully rated Neutral bus.
 5. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.

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- F Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Mechanical type.
 - 3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Sub-feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 6. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

- G Future Devices: All unused space(s) shall be fully provisioned and provided with mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

- H Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 DISTRIBUTION PANELBOARDS

- A Panelboards: NEMA PB 1, power and feeder distribution type.
 - 1. Enclosures for distribution type panelboards shall be a minimum of 10 inches deep by 36 inches wide.

- B Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

- C Mains: Circuit breaker or Lugs as shown on One Line Diagram.

- D Branch Overcurrent Protective Devices: Bolt-on circuit breakers.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

- B Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

- C Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuits interrupting rating as panelboard.
 - 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.

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- D Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.4 ELECTRONIC-GRADE PANELBOARDS

- A Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.
- B Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- C Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- D Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- E Buses:
 - 1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
 - 2. Copper equipment and isolated ground buses.
- F Surge Protection Device: IEEE C62.41-compliant, externally mounted, complying with UL 1449, 3rd edition and Specification 264313.

2.5 INTELLIGENT PANELBOARDS

- A Basis-of-Design Products: Subject to compliance with requirements, provide Powerlink MVP by Square D; a brand of Schneider Electric or comparable product by one of the following:
 - 1. Eaton Corp. Electrical Group
 - 2. Siemens
- B Power Supply: Self contained
- C Controller: Web based on RS485 Modbus network
 - 1. Provide with main circuit breaker metering where indicated on drawings and schedules.
 - 2. Provide with branch circuit metering where indicated on drawings and schedules.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A Basis-of-Design Products: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group or comparable product by one of the following
 - 1. Square D; a brand of Schneider Electric.
 - 2. Siemens

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- B The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.
- C Molded-Case Circuit Breaker (MCCB): Comply with UL 489, fully rated interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
 - a. Fixed instantaneous setting for circuit-breakers up to but not including 100 amps.
 - b. Adjustable instantaneous setting (up to ten times rated current) for circuit-breakers 100 amps and up to but not including 225 amps.
 2. Electronic trip circuit breakers, 225 amps and larger shall have RMS sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I²t response.
 3. Circuit breakers 800 A and larger shall be 100% rated for their input current.
 4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Single- and two-pole configurations with Class B ground-fault protection (30-mA trip).
 6. Multi-pole circuit breakers shall have common trip, use of handle ties is not permitted.
 7. Standard frame sizes, trip ratings, and number of poles.
 8. Application Listing: Appropriate for application. (e.g. HACR, SWD)
 9. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 10. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - b. Communication Capability: Communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - c. Shunt Trip: 120 -V trip coil energized from separate circuit.
 - d. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
 - e. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - f. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 - h. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
 - i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handles in on or off position.

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- j. Handle Clamp: Loose attachment, for holding circuit-breaker handles in on position.
- 11. New Circuit Breakers in Existing Panelboards:
 - a. Circuit breakers shall be of standard manufacture and match existing devices.
 - b. Circuit breakers shall have an AIC rating of not less than the lowest rated device in the panelboard.

2.7 PANELBOARD SUPPRESSORS

- A Subject to compliance with requirements, Surge Protection Devices shall be IEEE C62.41-compliant, externally mounted, and complying with UL 1449, 3rd edition and Specification 264313.

2.8 ACCESSORY COMPONENTS AND FEATURES

- A Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 EXECUTION

3.1 EXAMINATION

- A Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Install panelboards and accessories according to NEMA PB 1.1.

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- B Wall Mounted Panelboards: Do not attach directly to walls or structural surfaces. Attach panelboard to the vertical finished or structural surface behind the panelboard on channels such as "Unistrut".
- C Floor Mounted Panelboards: Install panelboards on 4 inch high concrete bases. Comply with requirements for concrete base specified in Division 03 Sections.
 - 1. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 3. Install anchor bolts to elevations required for proper attachment to panelboards.
- D Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- E Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration Controls for Electrical Systems."
- F Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated. Operating handle to be no more than 6'-7" AFF
- G Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- H Install overcurrent protective devices and controllers not already factory installed.
- I Provide GFI circuit breakers with 30 mA sensitivity trip for all freeze protection, temperature maintenance, and heat tracing circuits.
- J Install filler plates in unused spaces.
- K Circuit breaker handle locks shall be provided for all circuits that supply exit signs, emergency lights, energy management, and control system panels and fire alarm panels.
- L Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- M Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- N Comply with NECA 1.

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- O New circuit breakers installed in existing panelboards shall be of standard manufacture, shall match existing, and shall have an interrupting rating of not less than the lowest rated circuit breaker in the panelboard.
- P Provide all communications cabling and pathways required to allow Intelligent Panelboard metering to feed information to BAS system.

3.3 IDENTIFICATION

- A Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- D Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
 - 3. Comply with NETS.
- B Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each panelboard. Remove front so joints and connections are accessible to portable scanner.
 - 1. Instrument: Use an infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

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2. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial actions taken, and observations after remedial action.

D Panelboards will be considered defective if they do not pass tests and inspections.

- E Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 CLEANING

- A Vacuum dirt and debris from panelboard tubs; do not use compressed air to assist in cleaning.

3.6 ADJUSTING

- A Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Electrical System Studies."
- C Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.7 PROTECTION

- A Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 262416

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SECTION 262417
LOW VOLTAGE ROLL UP GENERATOR TERMINATION CABINET

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes Low Voltage Roll Up Generator Termination Cabinets (RUGTC) for use with AC circuits rated 600 V and less and having termination/lug landings for phase, neutral, and ground conductors for transitioning between portable load bank or portable generator and the facility switchgear.

1.3 DEFINITIONS

- A RUGTC: Roll Up Generator Termination Cabinet.

1.4 SUBMITTALS

- A Product Data: For termination cabinets.
- B Shop Drawings: For each unit. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
 - 1. Connection Wiring Diagrams.
 - 2. Nameplate legends.
 - 3. Bus capacities.
 - 4. Features, characteristics, ratings of each installed unit.
 - 5. Sample of proposed instructional signage.
- C Product certificates.
- D Operation and maintenance data.

1.5 QUALITY ASSURANCE

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- A Source Limitations: Obtain termination cabinet of a single type from single source from single manufacturer.
- B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.
- C Comply with NFPA 70.
- D UL 1773 listed, marked "Suitable for use on line side of service equipment".
- E Comply with Owner Design Standards.

PART 2 PRODUCTS

2.1 MANUFACTURED UNITS

- A Basis-of-Design Product: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group or comparable product by one of the following:
 - 1. Berthold Electric Company.
- B The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 FUNCTIONAL FEATURES

- A Description: An arrangement of buswork mounted on insulators in a weatherproof, permanently mounted cabinet with terminations for the temporary connection of a portable generator or portable load bank on the line side and permanent connections on the load side to the facility switchgear.

2.3 LINE TERMINATIONS (TEMPORARY)

- A Incoming Mains Access Location: Front.
- B Main Lugs, Incoming: Conductor connectors suitable for use with conductor material and sizes.
 - 1. Main and Neutral: Provide 400A cam locks suitable for connection to temporary generator

2.4 LOAD TERMINATIONS (PERMANENT)

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- A Outgoing Mains Access Location: Bottom.
- B Main Lugs, outgoing: Conductor connectors suitable for use with conductor material and sizes.
 - 1. Main and Neutral Lugs: Two-hole, long barrel compression type, CU only.

2.5 ENCLOSURES

- A Enclosures: Freestanding steel or aluminum cabinet unless otherwise indicated. NEMA 250, Type 3R unless otherwise indicated to comply with environmental conditions at installed location. Enclosure shall maintain NEMA 3R rating with temporary cables installed.
- B Enclosure Finish: Factory-applied polyester powder coat finish in manufacturer's standard ANSI 62 gray over a rust-inhibiting primer on treated metal surface.
- C Compartments: Access to the wiring compartment is through a full front, sturdy, continuous hinged door with padlock provisions.
- D Wiring Spaces:
 - 1. Access to the line side terminations is through a hinged door in the front of the enclosure. Front door must be opened. Access panel shall have up to 10 – 3" bushed openings with safety caps.
 - 2. The load side access is through a fixed bottom plate for terminating outgoing conduits.

2.6 CHARACTERISTICS AND RATINGS

- A Nominal System Voltage: 480/277 V, three phase, four wire.
- B Assembly Short-Circuit Current Rating: minimum 35,000 kA.
- C Continuous Rating: 2500 A.
- D Assembly Short-Circuit Current Rating: minimum 35,000 kA.
- E Phase and Neutral Buses: Uniform capacity for entire usable length.
- F Phase and Neutral Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated, 1000A/sq.in. current density mounted on insulators.

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- G Neutral Buses: 100 percent of the ampacity of phase buses, equipped with compression connectors for outgoing circuit neutral cables and mechanical connectors for incoming circuit neutral cables.
- H Ground Bus: Hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for equipment grounding conductors.
- I Front-Connected, Front-Accessible.

2.7 SOURCE QUALITY CONTROL

- A Testing: Inspect and test according to requirements in NEMA standard.
- B RUGTC will be considered defective if it does not pass tests and inspections.
- C Prepare test and inspection reports and submit to the Engineer.

PART 3 EXECUTION

3.1 INSTALLATION

- A Comply with NECA 1.
- B Install RUGTC on concrete base. Comply with requirements for concrete base specified in Division 03 Sections.
 - 1. The top of the concrete slab shall be approximately 4 inches (100-mm) above the finished grade. Edges shall be chamfered.
 - 2. For supported equipment, install epoxy-coated anchor bolts that anchor into structural concrete pad.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Provide four concrete filled bollards for protection from vehicular traffic, painted safety yellow.
- C Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.2 IDENTIFICATION

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- A Comply with requirements in Division 26 Section "Identification for Electrical Systems" for identification of components and wiring.
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label with engraved nameplate.
 - 3. Label with instructional sign.

3.3 WIRING INSTALLATION

- A Install wiring between terminal busses and switchgear. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Cables."
- B Bundle, train, and support wiring in enclosures.

3.4 CONNECTIONS

- A Comply with requirements for installation of conduit in Division 26 Section "Raceway and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.
- B Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."
- C Verify tightness and torque all accessible bolted electrical connections to manufacturer's specified values using a calibrated torque wrench.

3.5 FIELD QUALITY CONTROL

- A Perform tests and inspections.
- B Acceptance Testing Preparation:
 - 1. Inspect wiring, components, connections, and equipment installation.
 - 2. Test insulation resistance for each connecting supply circuit.
 - 3. Test continuity of each circuit.
 - 4. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

END OF SECTION 262417

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SECTION 262500
ENCLOSED BUS ASSEMBLIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes the following:
 - 1. Feeder-bus assemblies.
 - 2. Plug-in bus assemblies.
 - 3. Bus plug-in devices.

1.3 PERFORMANCE REQUIREMENTS

- A Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 ACTION SUBMITTALS

- A Shop Drawings: For each type of bus assembly and plug-in device.
 - 1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
 - 2. Show fittings, materials, fabrication, and installation methods for listed fire-stop barriers.
 - 3. Indicate required clearances, method of field assembly, and location and size of each field connection.
 - 4. Detail connections to switchgear, switchboards, and transformers.
 - 5. Wiring Diagrams: Power and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:

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1. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
 2. Clearances for access above and to the side of enclosed bus assemblies.
 3. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
 4. Support locations, type of support, and weight on each support.
- B Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
- C Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.
- D Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Plug-in Units: provide one (1) for each size installed, boxed and labeled.
 2. One set of joint covers for each busway, boxed and labeled.

1.8 QUALITY ASSURANCE

- A Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.
- B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NEC 368 and marked for intended use.
- C Comply with UL 857.
- D Comply with NEMA BU 1, "Busways."
- E Comply with NFPA 70.
- F Comply with Owner Design Standards.

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1.9 DELIVERY, STORAGE, AND HANDLING

- A Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

1.10 PROJECT CONDITIONS

- A Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 122 deg F (50 deg C).

1.11 COORDINATION

- A Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Basis of Design Products: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group. Other acceptable manufacturers the following:
 - 1. General Electric Company; Electrical Distribution & Control Division.
 - 2. Square D: Schneider Electric.
- B The listing of specific manufacturers above does not imply acceptance of products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 ENCLOSED BUS ASSEMBLIES

- A Feeder-Bus Assemblies : NEMA BU 1, low-impedance bus assemblies in non-ventilated housing; single-bolt joints; ratings as indicated.
 - 1. Voltage: 277/480 V; 3 phase; 100 percent neutral capacity.
 - 2. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 - 3. Bus Materials: High strength, 98% conductivity copper conductors fully insulated with Class B 130C insulation except at joints; plated surface at joints.

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4. Ground: 50 percent capacity internal bus bars of material matching bus material.
 5. Enclosure: Aluminum with finish of ANSI 61 epoxy powder paint.
 6. Joints shall be designed such that access is required to only one side of the busway for tightening joint bolts. It shall be possible to remove any joint and busway section without disturbing adjacent busway lengths.
 7. Fittings and Accessories: Manufacturer's standard.
 8. Mounting: Arranged flat, edgewise, or vertically without derating.
- B Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in non-ventilated housing; single-bolt joints; ratings as indicated.
1. Voltage: 277/480 V; 3 phase; 100 percent neutral capacity.
 2. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
 3. Bus Materials: High strength, 98% conductivity copper conductors fully insulated with Class B 130C insulation except at stabs and joints; plated surface at stabs and joints.
 4. Ground: 50 percent capacity internal bus bar of material matching bus material.
 5. Enclosure: Aluminum, with plug-in openings provided on both sides of the busway sections on 24-inch centers, hinged covers over unused openings. The design shall allow for ten (10) hinged cover outlets per ten (10) feet of plug-in length. Enclosure finish shall be ANSI 61 epoxy powder paint.
 6. Joints shall be designed such that access is required to only one side of the busway for tightening joint bolts. It shall be possible to remove any joint and busway section without disturbing adjacent busway lengths.
 7. Fittings and Accessories: Manufacturer's standard.
 8. Mounting: Arranged flat, edgewise, or vertically without derating.

2.3 PLUG-IN DEVICES

- A Molded-Case Circuit Breakers: NEMA AB 1; hook stick-operated handle, lockable with two padlocks, and interlocked with cover in closed position, with interrupting capacity to comply with available fault currents. Bus plugs to have interlock so plugs must be open to remove from bus
- B Accessories: Adjustable hook stick operator.

2.4 IDENTIFICATION

- A Label busways with voltage and source.
- B Plugs to be identified by their source and equipment fed

PART 3 EXECUTION

3.1 INSTALLATION

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- A Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to switchgear, switchboards, pipes, conduits, ceilings, and ducts.
 - 1. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
 - 2. Support bus assembly to prevent twisting from eccentric loading.
 - 3. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
 - 4. Fasten supports securely to building structure according to Division 26 Section "Hangers and Supports for Electrical Systems."
- B Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
- C Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 07 Firestopping Section and Owner Fire Protection Standards.
- D Install a concrete curb at least 4 inches (100 mm) high around bus-assembly floor penetrations.
- E Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
- F Tighten bus-assembly joints with calibrated torque wrench to the values recommended by the bus-assembly manufacturer. Re-Tighten joints again after bus assemblies have been energized for 30 days.
- G Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

3.2 CONNECTIONS

- A Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

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- B Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- D Remove and replace units that do not pass tests and inspections and retest as specified above.
- E Infrared Scanning: After Substantial Completion, but prior to beneficial occupancy, perform an infrared scan of all bus assembly including joints and plug-in units.
 - 1. Uses an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 - 2. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- F Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.4 ADJUSTING

- A Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Electrical System Studies."

3.5 CLEANING

- A Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.6 PROTECTION

- A Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 262500

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SECTION 262713
ELECTRICITY METERING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section includes equipment for electricity metering by the Utility Company.
- B Section includes equipment for sub-metering for LEED V4 credit for Advanced Energy Metering.
 - 1. Provide sub-meters, wiring, and accessories necessary to connect sub-meters to building automation system (BAS) provided in Division 23.
 - 2. Coordinate wire terminations and formatting of meter data with BAS installer as necessary to achieve functional system for compliance with LEED v4 Advanced Energy Metering credit.

1.3 ACTION SUBMITTALS

- A Product Data: For each type of product indicated.
- B Shop Drawings: For electricity-metering equipment.
 - 1. Dimensioned plans and sections or elevation layouts.
 - 2. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance.

1.4 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.
- B Comply with Owner Design Standards.

1.5 COORDINATION

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- A Electrical Service Connections: Coordinate with Utility Companies and components they furnish as follows:
 - 1. Comply with requirements of Utilities providing electrical power services.
 - 2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 PRODUCTS

2.1 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

- A Meters will be furnished by Utility Company.
- B Current-Transformer Cabinets: Provide equipment that complies with requirements of electrical-power Utility Company.
- C Meter Sockets: Provide equipment that complies with requirements of electrical-power Utility Company.
- D Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.
- E For services above 600 Volts: Where required, provide separate cubicles for utility metering equipment. Utility metering vertical section shall contain provisions for current transformers and voltage transformers as required by the Utility. The construction shall conform to the Utility Company's metering standards. It shall also conform to the general electrical and construction design of the switchgear specified. Obtain the Utility's approval of the cubicle arrangements prior to fabrication of the switchgear.

2.2 ELECTRICITY METERS

- A System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.
 - 1. Comply with ANSI C12.1 and ASNI C12.20 accuracy class
 - 2. Ambient temperatures: Minus 22 deg F to plus 158 deg F.
 - 3. Humidity: zero to 85%, noncondensing
 - 4. Capabilities and Characteristics:
 - a. Circuit Voltage, phase and amperage as shown on drawings.
 - b. Measure: kWh, onboard LED display
 - c. Remote-reading Options:None
- B General Requirements for Meters:
 - 1. Billing Meters Accuracy: 0.5 percent of reading, complying with ANSI C12.20.

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2. Certify that meters comply with ANSI C12.20 requirements by a laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). The laboratory shall use test equipment that is certified annually and is traceable to NIST standards.
 3. Enclosure: Supplied by meter manufacturer, NEMA 250, Type 1 minimum, with provisions for locking or sealing.
 4. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
 5. Onboard Nonvolatile Data Storage: kWh, until reset.
 6. Sensors: Current-sensing type, supplied by electronic meter manufacturer, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
 - a. Type: Split core, complying with recommendation of meter manufacturer.
- C kWh Meter: Electronic single and three phase meters, measuring electricity use.
1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kWh and current kilowatt load. Retain accumulated kWh in a nonvolatile memory, until reset.
- D kWhd Meter: Electronic single-phase and three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.
1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating the following:
 - a. Accumulative kWh.
 - b. Current time and date.
 - c. Current demand.
 - d. Historic peak demand.
 - e. Time and date of historic peak demand.
 3. Retain accumulated kWh and historic peak demand in a nonvolatile memory, until reset.
- E Power Quality Meter: Electronic three-phase Tier 1 meter and incoming mains to measure power quality including:
1. power quality health
 2. Event sequence
 3. Waveform capture and analysis
 4. Demand profile
 5. Energy use analysis
 6. Multichannel waveforms
 7. Harmonic analysis
- F Remote Reading Options:
1. Serial Interface: Serial Interface: RS-485 for BACnet IP protocol
 2. TCP/IP adapter for BACnet IP protocol.

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- G Current-Transformer Cabinet: Size and configuration as recommended by metering equipment manufacturer for use with indicated connected feeder and sensors.

PART 3 EXECUTION

3.1 INSTALLATION

- A Comply with equipment installation requirements in NECA 1.
- B Install meters furnished by Utility Company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by Utility Company.
- C Contractor shall be responsible for coordinating the installation of any utility metering equipment by utility personnel.

3.2 IDENTIFICATION

- A Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A Perform tests and inspections.
 - 1. Comply with Utility Company requirements.
- B Electricity metering will be considered defective if it does not pass Utility's tests and inspections.

END OF SECTION 262713

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SECTION 262726
WIRING DEVICES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B "Lighting Control Devices" for wall box dimmers, wall box dimmers/sensors, and wall box occupancy sensors.
- C Owner IT/IS Standards for Telecommunications devices.

1.2 SUMMARY

- A Section Includes:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Weather-resistant receptacles.
 - 3. Twist-locking receptacles.
 - 4. Cord and plug sets.
 - 5. Toggle Switches.
 - 6. Floor service outlets.

1.3 DEFINITIONS

- A EMI: Electromagnetic interference.
- B GFCI: Ground-fault circuit interrupter.
- C Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D RFI: Radio-frequency interference.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.

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1.5 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.
- B Comply with NFPA 70.
- C Comply with NFPA 99.
- D Comply with Owner Design Standards.
- E Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

1.6 ACTION SUBMITTALS

- A Product Data: For each type of product.
- B Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

1.7 INFORMATIONAL SUBMITTALS

- A Field quality-control reports.

1.8 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A Wiring Devices, Components, and Accessories: UL listed and labeled as defined in NFPA 70 and marked for intended location and application.

2.2 STRAIGHT-BLADE RECEPTACLES

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- A Convenience Receptacles, 125 V, 20 A: Heavy duty specification grade complying with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5351 (single), CR5362 (duplex).
 - b. Hubbell; HBL5351 (single), HBL5352 (duplex).
 - c. Pass & Seymour; 5361 (single), 5362 (duplex).
 - d. Leviton; 5351

2.3 GFCI RECEPTACLES

- A General Description:
1. Straight blade, non-feed through type.
 2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943, Class A, and FS W-C-596.
 3. Include correct wiring/trip indicator light.
- B Duplex GFCI Convenience Receptacles, 125 V, 20 A:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; VGF20.
 - b. Hubbell; GFR5352L.
 - c. Pass & Seymour; 2095.
 - d. Leviton; 7899-FE

2.4 RECEPTACLES FOR SPECIAL EQUIPMENT

- A Specialized Receptacles: Comply with NEMA WD 1, NEMA WD 6 for standard configurations and UL 498.
- B Products: Subject to compliance with requirements, provide one of the following:
1. Cooper.
 2. Hubbell.
 3. Pass & Seymour.
 4. Leviton.

2.5 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

- A Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper Crouse-Hinds.
 - b. EGS/Appleton Electric.
 - c. Killark; Division of Hubbell Inc.

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- B Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6, Configuration L5-20R, and UL 498.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; CWL520R.
 - b. Hubbell; HBL2310.
 - c. Pass & Seymour; L520-R.
 - d. Leviton; 2310
- C Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; IGL520R.
 - b. Hubbell; IG2310.
 - c. Pass & Seymour; IG4700.
 - d. Leviton; 2310-IG
 2. Description:
 - a. Comply with NEMA WD 1, NEMA WD 6, Configuration L5-20R, and UL 498.
 - b. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.6 CORD AND PLUG SETS

- A Description:
1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
 3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 TOGGLE SWITCHES

- A Comply with NEMA WD 1, UL 20, and FS W-S-896.
- B Switches, 120/277 V, 20 A:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Single Pole:
 - 1) Cooper; AH1221.
 - 2) Hubbell; HBL1221.
 - 3) Pass & Seymour; CSB20AC1.
 - 4) Leviton; 1221-2
 - b. Two Pole:

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- 1) Cooper; AH1222.
 - 2) Hubbell; HBL1222.
 - 3) Pass & Seymour; CSB20AC2.
 - 4) Leviton; 1222-2
 - c. Three Way:
 - 1) Cooper; AH1223.
 - 2) Hubbell; HBL1223.
 - 3) Pass & Seymour; CSB20AC3.
 - 4) Leviton; 1223-2
 - d. Four Way:
 - 1) Cooper; AH1224.
 - 2) Hubbell; HBL1224.
 - 3) Pass & Seymour; CSB20AC4.
 - 4) Leviton; 1224-2
- C Pilot-Light Switches, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; AH1221PL for 120 and 277 V.
 - b. Hubbell; HBL1201PL for 120 and 277 V.
 - c. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277 V.
 - d. Leviton; 1221-7PR
 - 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."
- D Key-Operated Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following :
 - a. Cooper; AH1221L.
 - b. Hubbell; HBL1221L.
 - c. Pass & Seymour; PS20AC1-L.
 - d. Leviton; 1221-2GL
 - 2. Description: Single pole, with factory-supplied key in lieu of switch handle. Provide six (6) spare keys.

2.8 WALL PLATES

- A Single and combination types shall match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces:
 - a. 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.
 - 3. Material for Unfinished Spaces: 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.
 - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

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- B Wet-Location, Weatherproof-in-use Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.9 FLOOR SERVICE FITTINGS

- A Coordinate fittings with floor boxes as described in Section 260533.
- B Type: Modular, flush-type, dual-service units suitable for wiring method used.
- C Compartments: Barrier separates power from voice and data communication cabling.
- D Service Plate: Rectangular die-cast aluminum with satin finish.
- E Power Receptacle: NEMA WD 6 Configuration 5-20R, unless otherwise indicated.
- F Voice and Data Communication Outlet: Comply with Owner IT/IS Department Standards.

2.10 FINISHES

- A Device Color:
 - 1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Emergency Power System: Red.
 - 3. Isolated-Ground Receptacles: Orange.
 - 4. UPS: Blue.
- B Wall Plate Color: For non-metallic covers, match device color.

PART 3 EXECUTION

3.1 INSTALLATION

- A Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B Wiring Devices shall be provided where required by the Project requirements and as follows:
 - 1. Office and Administrative areas, Corridors: heavy duty, specification grade.
 - 2. Mechanical and Electrical rooms, storerooms, EVS, toilet rooms (staff): heavy duty, specification grade.
 - 3. Toilet rooms (public, patient care areas): GFCI, tamper resistant, hospital grade.
 - 4. Provide GFCI type devices as indicated and where required by Codes and Standards.

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C Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

D Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pig-tailing existing conductors are permitted, provided the outlet box is large enough.

E Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. "Daisy-chaining" of receptacles is not permitted.
6. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
7. Use a torque screwdriver when a torque is recommended or required by manufacturer.
8. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
9. Tighten unused terminal screws on the device.
10. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

F Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

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- G Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- H Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
- I Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.
- J Devices installed in MRI Suites shall be Hospital Grade of completely non-magnetic design.
- K Devices installed in pediatric waiting rooms, exam rooms, treatment rooms and similar shall be Hospital Grade, tamper-resistant design.

3.2 IDENTIFICATION

- A Comply with Division 26 Section "Identification for Electrical Systems."
- B Identify each receptacle with panelboard identification and circuit number. Use hot, stamped or engraved machine printing with white-filled lettering on black field, self adhesive nameplate attached to face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

- A Perform the following tests and inspections:
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- B Tests for Convenience Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C Test straight-blade hospital-grade convenience outlets for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

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- D Wiring device will be considered defective if it does not pass tests and inspections.
- E Prepare test and inspection reports.

END OF SECTION 262726

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SECTION 262733
POWER DISTRIBUTION UNITS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Power distribution units (PDUs).

1.2 RELATED REQUIREMENTS

- A Section 260529 - NOT OEC EDITED2 - Hangers and Supports for Electrical Systems.

1.3 REFERENCE STANDARDS

- A NEMA PB 1 - Panelboards; 2011.
- B NEMA ST 20 - Dry Type Transformers for General Applications; 2021.
- C NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 SUBMITTALS

- A See Section 013000 - Administrative Requirements, for submittal procedures.
- B Shop Drawings: Indicate cable lengths and construction, circuit arrangements and directory, control system wiring diagram, connection diagram for external wiring, and details of conduit and wiring connections and terminations.
 - 1. Identify mounting conditions required for equipment seismic qualification.
- C Product Data: Provide electrical characteristics and connection requirements for unit and accessories.
- D Operation Data: Start-up and resetting unit.
- E Maintenance Data: Instructions for cleaning methods, recommended cleaning materials, addition and modification of branch circuit arrangements, repair and parts replacement.
- F Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

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1. See Section 016000 Product Requirements 016000 - NOT OEC EDITED - Product Requirements, for additional provisions.
2. Extra Control Circuit Fuses: One extra of each type and size.
3. Extra Cables and Connectors: One extra of each type and size.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.
- B Products: Listed, classified, and labeled as suitable for the purpose intended.
- C Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Protect products from moisture and dust by storing them in a clean, dry location remote from areas involved in construction operations. Provide additional protection in accordance with manufacturer's instructions.

1.7 FIELD CONDITIONS

- A Do not install until building finishes are complete.
- B Maintain temperature between 32 degrees F (0 degrees C) and 104 degrees F (40 degrees C) during and after installation of units.
- C Maintain relative humidity between 0 percent and 95 percent (noncondensing) during and after installation of units.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Controlled Power Company: www.controlledpwr.com/#sle.
- B Schneider Electric: www.se.com/#sle.
- C Vertiv Co: www.vertivco.com/#sle.

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2.2 POWER DISTRIBUTION UNITS

- A Power Distribution Unit: providing surge protection, harmonic filters, isolation transformer, voltage regulation, and branch circuit overcurrent protective devices.
- B Service Conditions:
1. Temperature: 32 degrees F (0 degrees C) and 104 degrees F (40 degrees C).
 2. Humidity: Less than 95 percent humidity (non-condensing).
 3. Altitude: Less than 3,300 feet (1,000 meters) above sea level.
- C Ratings:
1. System Continuous Rating: As indicated on Drawings.
 2. Input Voltage Rating: 277/480 volts, 1 phase.
 3. Output Voltage Rating: 120/208 volts, 1 phase.
 4. Impedance: 3 percent, maximum.
 5. Input Voltage Limits: plus 10, minus 20 percent.
 6. Frequency: 60 plus or minus 3 Hz.
 7. Load Power Factor: Capable of operating between 60 percent lagging and 60 percent leading power factor.
 8. Harmonic Distortion of Input Current Wave Form: 5 percent maximum at full load.
 9. Output Voltage Regulation: plus 6, minus 8 percent.
 10. Output Harmonic Distortion: Maximum 2 percent rms total harmonic distortion.
 11. Three-phase Overload Ratings:
 - a. 500 percent for 1 cycle.
 - b. 100 percent for 10 seconds.
 12. Response Time: 100 percent correction in 1 cycles.
 13. Audible Noise: Less than 52 dBA at distance of 3 feet (1 m) in non-reverberating environment.
 14. Normal Mode Attenuation: 32 dB, 10 Hz. to 1 MHz.
 15. Common Mode Attenuation: 126 dB.
- D Isolation Transformer: NEMA ST 20, factory-assembled, air cooled dry type shielded isolation transformer, ratings to match unit ratings specified.
1. Insulation System: Class 220C, with 150 degree C average winding temperature rise.
 2. Winding Taps: NEMA ST 20.
 3. Sound Levels: NEMA ST 20.
 4. Basic Impulse Level: 10 kilo volts.
 5. Ground core and coil assembly to enclosure using a visible flexible copper grounding strap.
 6. Provide electrostatic winding shield with separate insulated grounding connection.
 7. Coil Conductors: Continuous windings with terminations brazed or welded.
 8. Isolate core and coil from enclosure using vibration-absorbing mounts.
- E Branch Circuit Panelboard: NEMA PB 1, circuit breaker type, with bus ratings to match unit capacity specified. Provide copper ground bus and double capacity neutral bus.

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- F Molded Case Circuit Breakers: Plug-in type thermal magnetic trip circuit breakers, with common trip handle for all poles; UL listed.
- G Enclosure: Allow access from front for servicing adjustments and connections, with access through hinged door equipped with tumbler lock and latch handle.
 - 1. Cooling: Forced convection.
 - 2. Equip air inlet with permanent filters and pressurize cabinet to prevent entry of dirt.
 - 3. Equip cabinet for fork truck lifting.
 - 4. Identify internal wiring at each end of conductor.
 - 5. Electroplate brackets and securing hardware with corrosion resistant material. Secure bolts, studs and nuts with lockwashers.
 - 6. Cabinet Finish: Manufacturer's standard finish.
 - 7. Cabinet Finish: Primed and painted inside and outside with gray semi-gloss enamel.

2.3 CONTROLS AND INDICATORS

- A Controls: AC input circuit breaker; INDICATOR TEST switch.
- B Indicators: Provide audible and visual alarm indication of abnormal conditions.
 - 1. Output Overvoltage: Higher than 6 percent above rated.
 - 2. Output Undervoltage: Less than 13 percent below rated.
 - 3. Transformer Overtemperature: Temperature higher than 180 degrees C.
- C Meters: Use 1 percent accuracy meters.
 - 1. Voltage: Input and output, phase-phase and phase-neutral.
 - 2. Current: Input and output, each phase; output neutral current; ground current.
 - 3. Apparent Power: Output kVA.

2.4 ACCESSORIES

- A Remote Emergency Power Off Switches: Switch assembly with normally open contact mounted in painted wall box. Provide three conductor cable for connection to unit.
- B Transient Suppression Plate: Copper, 3 feet (1 m) square.

2.5 SOURCE QUALITY CONTROL

- A See Section 014000-Quality Requirements, for additional requirements.
- B Provide inspection and testing for completed power distribution units.

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- C Make completed power distribution units available for inspection at manufacturer's factory prior to packaging for shipment. Notify Owner at least 7 days before inspection is allowed.

PART 3 EXECUTION

3.1 EXAMINATION

- A Verify that field measurements are as indicated.

3.2 INSTALLATION

- A Install in accordance with manufacturer's instructions.
- B Provide required support and attachment in accordance with Section 260529.
- C Locate emergency power off switches on wall outside UPS room.

3.3 FIELD QUALITY CONTROL

- A See Section 014000-Quality Requirements, for additional requirements.
- B See Section , for additional requirements.
- C Measure output voltage of branch circuit panelboard.
- D Inspect installation to assure units are properly grounded.

3.4 ADJUSTING

- A Adjust settings in accordance with manufacturer's instructions.

3.5 CLOSEOUT ACTIVITIES

- A See Section 017800 Closeout Submittals, for closeout submittals.
- B See Section 017900- Demonstration and Training, for additional requirements.
- C Demonstrate operation of unit.

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3.6 MAINTENANCE

- A See Section 017000 Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B Provide a separate maintenance contract for specified maintenance service.
- C Provide service and maintenance of power distribution units for one year from Date of Substantial Completion.

END OF SECTION 262733

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SECTION 262813
FUSES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes:
1. Cartridge fuses rated 600-V ac and less for use in:
 - a. Control circuits.
 - b. Enclosed controllers.
 - c. Enclosed switches.
 - d. Elevator switches.
 2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

- A Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 3. Current-limitation curves for fuses with current-limiting characteristics.
 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
 5. Coordination charts and tables and related data.
 6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:

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1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three (3) of each size and type.

1.6 QUALITY ASSURANCE

- A Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.
- B Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.
- C Comply with NEMA FU 1 for cartridge fuses.
- D Comply with NFPA 70.

1.7 PROJECT CONDITIONS

- A Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C) apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.8 COORDINATION

- A Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 PRODUCTS

2.1 MANUFACTURERS

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- A Basis-of-Design Product: Subject to compliance with requirements, provide products by Cooper Bussmann, Inc. (Eaton Corp. Electrical Group) or comparable product by one of the following:
 - 1. Mersen USA (Ferraz Shawmut)
- B The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

2.2 CARTRIDGE FUSES

- A Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 SPARE-FUSE CABINET

- A Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Finish: Gray, baked enamel.
 - 3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
 - 4. Fuse Pullers: Provide for each size of fuse.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

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A Provide fuses in accordance with Division 26 Section "Electrical System Studies ".

B Cartridge Fuses: (for review)

1. Motor Branch Circuits: Class RK1, time delay.
2. Other Branch Circuits: Class RK1, time delay.
3. Elevator Branch Circuits: Class J, fast acting.
4. Control Circuits: Class CC, time delay, and control transformer duty.

3.3 INSTALLATION

A Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B Install spare-fuse cabinet(s) in electric rooms and mechanical rooms, stock with spares and fuse pullers.

3.4 IDENTIFICATION

A Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, and holder.

END OF SECTION 262813

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SECTION 262816
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section Includes:
1. Fusible switches.
 2. Non-fusible switches.
 3. Shunt trip switches.
 4. Molded-case circuit breakers (MCCBs).
 5. Molded-case switches.
 6. Enclosures.
- B Related Sections:
1. Division 26 Section "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.

1.3 DEFINITIONS

- A NC: Normally closed.
- B NO: Normally open.
- C SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

- A Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

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- A Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 - 5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.
- B Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

- A Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C Manufacturer's field service report.

1.7 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

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1.8 MAINTENANCE MATERIAL SUBMITTALS

- A Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses no fewer than three (3) of each size and type.
 - 2. Fuse Pullers: one for each size and type.

1.9 QUALITY ASSURANCE

- A Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.
- D Comply with NFPA 70.
- E Series rated equipment shall not be used.

1.10 PROJECT CONDITIONS

- A Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2010 m).

1.11 COORDINATION

- A Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 PRODUCTS

2.1 FUSIBLE SWITCHES

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- A Basis-of-Design Product: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group or comparable product by one of the following:
 - 1. Square D; a brand of Schneider Electric.
 - 2. Siemens

- B Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

- C Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 5. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 - 6. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 7. Lugs: Mechanical type, suitable for number, size, and conductor material.
 - 8. Service-Rated Switches: Labeled for use as service equipment.
 - 9. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

- A Basis-of-Design Product: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group or comparable product by one of the following:
 - 1. Square D; a brand of Schneider Electric.
 - 2. Siemens

- B Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

- C Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.

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5. Hookstick Handle: Allows use of a hookstick to operate the handle.
6. Lugs: Mechanical type, suitable for number, size, and conductor material.
7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 SHUNT TRIP SWITCHES

- A Basis-of-Design Product: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group or comparable product by one of the following:
1. Cooper Bussmann, Inc.
 2. Mersen USA (Ferraz Shawmut, Inc.)
- B General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.
- C Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
- E Accessories:
1. Oiltight key switch for key-to-test function.
 2. Oiltight red ON pilot light.
 3. Isolated neutral lug; 100 percent rating.
 4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
 5. Form C alarm contacts that change state when switch is tripped.
 6. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
 7. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.4 MOLDED-CASE CIRCUIT BREAKERS

- A Basis-of-Design Product: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group or comparable product by one of the following:
1. Square D; a brand of Schneider Electric.
 2. Siemens
- B The listing of specific manufacturers above does not imply acceptance of their products that do not meet the specified ratings, features and functions. Manufacturers listed above are not relieved from meeting these specifications in their entirety.

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- C Molded-Case Circuit Breaker (MCCB): Comply with UL 489, fully rated interrupting capacity to meet available fault currents. Use of series rated equipment is prohibited.
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits.
 - a. Fixed instantaneous setting for circuit-breakers up to but not including 100 amps.
 - b. Adjustable instantaneous setting (up to ten times rated current) for circuit-breakers 100 amps and up to but not including 225 amps.
 2. Electronic trip circuit breakers, 225 amps and larger shall have RMS sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I₂t response.
- D Circuit breakers 800 amps and larger shall be 100% rated for their input current.
- E Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- F Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: Single- and two-pole configurations with Class B ground-fault protection (30-mA trip).
- G Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 5. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system, specified in Division 26 Section "Electrical Power Monitoring and Control."
 6. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 7. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 8. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
 10. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 11. Electrical Operator: Provide remote control for on, off, and reset operations.

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12. Accessory Control Power Voltage: Integrally mounted, self-powered.

2.5 ACCESSORIES

- A Communication modules: Where indicated provide communication modules, energy metering and control for circuit breakers and switches, with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control." Communications link shall be via Owner's energy management software.

2.6 ENCLOSURES

- A Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 3R.
 3. Kitchen, Wash-Down Areas, Other Wet or Damp Indoor Locations: NEMA 250, Type 4X, stainless steel.
 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 5. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration Controls for Electrical Systems."
- C Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

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- D Install wiring between circuit breakers and switches, and facility's EPMC system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."
 - 1. Install all low voltage wiring (CAT. 6, twisted pair, etc.) between energy metering devices and owner's network
- E Install fuses in fusible devices in accordance with Division 26 Section "Electrical System Studies".
- F Provide GFI circuit breakers with 30 mA sensitivity trip for all freeze protection, temperature maintenance, and heat tracing circuits.
- G Comply with NECA 1.

3.3 IDENTIFICATION

- A Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each device. Remove front and rear panels so joints and connections are accessible to portable scanner.

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1. Instrument: Use an infrared-scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 2. Record of Infrared Scanning: Prepare a certified report that identifies devices checked and that describes infrared-scanning results. Include notation of deficiencies detected, remedial actions taken, and observations after remedial action.
- E Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- F Prepare test and inspection report, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

- A Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Electrical System Studies ".

END OF SECTION 262816

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SECTION 262913
ENCLOSED CONTROLLERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section includes controllers separately enclosed, rated 600 V and less:
 - 1. Full-voltage manual.
 - 2. Full-voltage magnetic.
- B Related Section:
 - 1. Division 23 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on variable torque loads in ranges up to 200 hp.
 - 2. Division 26 Section "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.

1.3 DEFINITIONS

- A CPT: Control power transformer.
- B MCCB: Molded-case circuit breaker.
- C N.C.: Normally closed.
- D N.O.: Normally open.
- E OCPD: Overcurrent protective device.

1.4 ACTION SUBMITTALS

- A Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.

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- B Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
1. Show tabulations of the following:
 - a. Each installed unit's type and details.
 - b. Factory-installed devices.
 - c. Nameplate legends.
 - d. Short-circuit current rating of integrated unit.
 - e. Listed and labeled for integrated short-circuit current (withstand) rating of OCPD's in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - f. Features, characteristics, ratings, and factory settings of individual OCPD's in combination controllers.
 2. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A Field quality-control reports.
- B Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.6 CLOSEOUT SUBMITTALS

- A Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Routine maintenance requirements for enclosed controllers and installed components.
 2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCCB trip settings.
 3. Manufacturer's written instructions for setting field-adjustable overload relays.

1.7 MATERIALS MAINTENANCE SUBMITTALS

- A Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

1.8 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.

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- B Comply with NFPA 70.
- C Comply with Owner Design Standards.
- D Use of IEC rated components is prohibited.
- E Controllers shall be a minimum of NEMA size 1.

1.9 DELIVERY, STORAGE, AND HANDLING

- A Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers.

1.10 PROJECT CONDITIONS

- A Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2010 m).

1.11 COORDINATION

- A Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 PRODUCTS

2.1 MANUFACTURERS

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- A Basis-of-Design Products: Subject to compliance with requirements, provide products by Eaton Corp. Electrical Group or comparable product by one of the following:
1. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 2. Square D; a brand of Schneider Electric.

2.2 FULL-VOLTAGE CONTROLLERS

- A General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
1. Configuration: Non-reversing.
 2. Surface or flush mounting as indicated on drawings.
 3. Red "running" pilot light.
- C Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Configuration: Non-reversing.
 2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
 3. Flush or Surface mounting.
 4. Red "running" pilot light.
- D Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Configuration: Non-reversing.
 2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 20 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type.
 3. Flush or Surface mounting.
 4. Red "running" pilot light.
 5. -MAKE A SELECTION- auxiliary contact.
- E Magnetic Controllers: Full voltage, across the line, electrically held.
1. Configuration: Non-reversing.
 2. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 3. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

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4. Control Circuits 120 V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: 100 VA.
 5. Bi-Metallic Thermal Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 20 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Isolated alarm contact.
 6. External overload reset push button.
- F Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means
1. MCCB Disconnecting Means:
 - a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
 - b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.

2.3 ENCLOSURES

- A Separately Mounted Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: Type 1.
 2. Outdoor Locations: Type 3R.
 3. Kitchens, Wash-Down Areas, Other Wet Indoor Locations: Type 4X, stainless steel.
 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
 5. Hazardous Areas Indicated on Drawings: Type 7 or Type 9 as indicated.

2.4 ACCESSORIES

- A General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
1. Push Buttons, Pilot Lights, and Selector Switches: Heavy, oil-tight type.
 - a. Push Buttons: Shrouded types; maintained or momentary as indicated.
 - b. Pilot Lights: LED types; colors as indicated; push to test.
 - c. Selector Switches: Rotary type.
- B Reversible N.C. /N.O. auxiliary contact(s) as indicated.

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- C Control Relays: Auxiliary and adjustable solid-state time-delay relays as indicated.
- D Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays as indicated: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
- E Communications Modules: Where indicated provide communication modules, energy metering and control in motor starters with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control." Communications link shall be via Owner's energy management software.
- F Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4X, Type 7, Type 9 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- G Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- H Cover gaskets for Type 1 enclosures.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- C Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- B Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Division 03 Sections.

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1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D Install fuses in each fusible-switch enclosed controller in accordance with Division 26 Section "Electrical System Studies".
- E Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- F Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- G Comply with NECA 1.

3.3 IDENTIFICATION

- A Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 2. Label each enclosure with engraved nameplate.
 3. Label each enclosure-mounted control and pilot device.

3.4 CONTROL WIRING INSTALLATION

- A Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."
1. Install all low voltage wiring (CAT. 6, twisted pair, etc.) between energy metering devices and Owner's network.
- B Bundle, train, and support wiring in enclosures.
- C Connect selector switches and other automatic-control selection devices where applicable.

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1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages.
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B Enclosed controllers will be considered defective if they do not pass tests and inspections.

C Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.6 ADJUSTING

A Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

B Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C Adjust the trip settings of thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required).

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- D Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Electrical System Studies."

3.7 CLEANING

- A Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.8 PROTECTION

- A Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

- A Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 262913

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SECTION 263213
ENGINE GENERATORS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes packaged, engine-generator sets for Level 1 emergency power supply with the following features:
1. Diesel engine.
 2. Unit-mounted cooling system.
 3. Unit-mounted control and monitoring.
 4. Performance requirements for sensitive loads.
 5. Integral fuel tank.
 6. Network Communications.
 7. Outdoor enclosure.
- B Related Sections:
1. Division 23 Section 231113 "Facility Fuel Oil Piping" for fuel storage, pumping systems and piping.
 2. Division 26 Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.
 3. Division 26 Section 262313 "Paralleling Low Voltage Switchgear" for requirements for paralleling of multiple generator installations.

1.3 DEFINITIONS

- A Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 SUBMITTALS

- A Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
1. Thermal damage curve for generator.

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2. Catalog data for generator protective device.
 3. Time-current characteristic curves for generator protective device.
- B Shop Drawings: "Typical" drawings are not acceptable. Provide project specific drawings for engine-generator and all specified components. Drawings shall detail equipment assemblies and indicate dimensions, weights, loads, and required clearances, method of field assembly, components, and location and size of each field connection.
1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified including enclosure.
 2. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 3. Wiring Diagrams: Power, signal, and control wiring.
- C Qualification Data: For manufacturer.
- D Source quality-control test reports.
1. Certified summary of prototype-unit test report.
 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
 4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 5. Report of sound generation.
 6. Report of exhaust emissions showing compliance with applicable regulations.
 7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- E Field quality-control test reports.
- F Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
- G Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.

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- B Manufacturer Qualifications: A qualified manufacturer. Maintain, within 50 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by UL and marked for intended use.
- E Comply with ASME B15.1.
- F Comply with NFPA 30.
- G Comply with NFPA 37.
- H Comply with NFPA 70.
- I Comply with NFPA 99.
- J Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- K Comply with latest EPA Tier requirements.
- L Comply with FM Global requirements.
- M Comply with Owner Design Standards.
- N Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- O Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 PROJECT CONDITIONS

- A Products Selection for Restricted Space: Drawings indicate maximum dimensions for generators including clearances between generators and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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- B Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: Minus 15 to plus 40 deg C.
 - 2. Altitude: Sea level to 1000 feet (300 m).

1.7 COORDINATION

- A Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

- A Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

- A Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.10 EXTRA MATERIALS

- A Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Three for each battery charger and control panel.
 - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Caterpillar; Engine – Generator Division.

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2.2 ENGINE-GENERATOR SET

- A Factory-assembled and -tested, engine-generator set.
- B Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
 - 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
 - 2. Each engine-generator specified for parallel operation shall be configured for automatic parallel operation. Each engine-generator shall be capable of parallel operation with one or more engine-generators on an isolated bus.
 - 3. Each engine-generator specified for parallel operation shall be configured to automatically load-share with other engine-generators by proportional loading.
 - 4. Output Connections: Three-phase, four-wire.
 - 5. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D Generator-Set Performance:
 - 1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
 - 2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
 - 3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
 - 4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
 - 5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 - 6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
 - 7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

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8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.
11. Accept rated load in one step.

2.3 ENGINE

- A Fuel: Fuel oil, Grade DF-2.
- B Rated Engine Speed: 1800 rpm.
- C Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D Lubrication System: The following items are mounted on engine or skid:
1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E Engine Fuel System:
1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G Governor: Adjustable isochronous, with speed sensing.
- H Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

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3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- I Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 25 dB at 500 Hz.
 2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
 3. Factory installed inside sound attenuated housing and piped.
 4. Weather-cap on outlet.
- J Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K Starting System: up to and including 250 kW 12-V electric, with negative ground; greater than 250 KW 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Dual cranking motors. For Units greater than 1000 KW
 4. Cranking Cycle: As required by NFPA 110 for system level specified.
 5. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging. Battery shall be maintenance free, sealed lead acid type. No Wet Cell Or NiCad
 6. Battery bank for each cranking motor. For Units greater than 1000 KW
 7. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
 8. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Include accessories required to support and fasten batteries in place.
 9. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 10. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

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- a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
- b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
- c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
- d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
- e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
- g. Provide one charger for each battery bank, provide products by La Marche.

2.4 FUEL OIL STORAGE

- A Comply with NFPA 30, NFPA 37, and applicable State Code.
- B Fuel Supply Tank: Comply with UL 142, skid base, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
 - 1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
 - 2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of minimum 24 hours' operation at 100 percent of rated power output of engine-generator system without being refilled, or to a maximum of 660 gallons. The skid base tank shall not be less than 12 inches in height
 - 3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 - 4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
 - 5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
 - 6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve. The fuel tank shall be equipped with a manual fuel level gauge capable of being seen by the operator to determine the fuel level in the tank.
 - 7. Tank shall comply with all local, state and federal laws

2.5 LOAD CONTROL MODULE AND MONITORING SYSTEM:

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- A Provide an independent load control panel to monitor and control the operation of the system loads. The load control module shall be capable of controlling up to eight (8) sequenced levels of load add and load shed. The load control module shall be capable of monitoring and controlling load sequence for a single generator in a stand-alone system or up to four (4) generators when utilized in an isolated bus paralleling system. The load control module shall be manufactured by the generator set manufacturer to assure factory tested and seamless integration with the generator set controllers. Each panel shall contain the components and devices as described in this section.

1. Construction

- a. The Load Control System should be housed either fully incorporated into the switchgear when utilized in paralleled systems or housed separately in a standalone enclosure.
- b. The enclosure frame shall be welded and constructed of a minimum of 12 gauge steel.
- c. The enclosure shall be painted smooth ANSI 61 Gray and the interior subpanels shall be full height of the enclosure, constructed of a minimum 14 gauge painted steel.
- d. The enclosure shall be provided with mounting holes on the back of the enclosure
- e. The enclosure shall include slotted flush latches
- f. The enclosure shall be NEMA 1.
- g. All interior panels and doors shall be bonded to the grounding terminal
- h. The Load Control System shall be listed and labeled under the requirements of UL 891 or UL508A, including all covers, barriers, and supports. Individual control sections shall be isolated from each other by metal or insulating barriers.
- i. All wiring shall be UL listed 105 degree C, 600 volt rated, and sized as required. Each wire, device or function shall be suitably identified by silk-screen or similar permanent identification.
- j. All field control interconnecting wiring shall be sized as specified by system manufacturer (wiring not designated by the system manufacturer shall be minimum 14 AWG copper). All control interconnect wiring shall be stranded.
- k. All active control system components in the system shall be suitable for operation in ambient temperatures ranging from 0 to +50 degrees C. The active control electronics shall be environmentally protected from dust, dirt, and humidity. The controls shall be suitable for operation in an ambient ranging from 10-90% relative humidity, and shall be protected from the effects of equipment vibration.
- l. The Touchscreen and other non-LED displays specified shall be suitable for operation from 0- +50 degrees C. The controls shall be suitable for operation in an ambient ranging from 10-90% relative humidity.

B Additional Components Required

C Main Controller

1. The Main controller of the Load Control System shall be a Programmable Logic Controller (PLC). Acceptable Manufacturers are:
 - a. Schneider Electric (Modicon)
2. The PLC and associated I/O components shall have the following minimum specifications:
 - a. 0-60 degree C operating temperature
 - b. -40 to 85 degree C storage temperature

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- c. 19Vdc to 30Vdc operating voltage
 - d. LED diagnostics for troubleshooting.
 - 3. The PLC shall use primarily a distributed I/O configuration to reduce the amount of interconnect wiring.
 - 4. PLC languages used shall comply with IEC 61131.
 - 5. The PLC programming software shall automatically keep track of each change by recording the build version. This version shall be available on the diagnostics screen in the HMI
 - 6. The PLC programming software vendor shall maintain additional tools to allow for the ability to automatically and graphically display the differences between two program versions.
 - 7. The PLC I/O shall be primarily of a distributed I/O architecture with the I/O placed as close as possible to the device being controlled to limit the amount of interconnect wiring and reduce field wiring mistakes. Typically this would consist of the I/O being mounted on a din rail in the switchgear enclosure.
- D Operator Panel
- 1. The Operator Panel shall be Touchscreen.
 - a. Touchscreen 24VDC power supply.
 - b. The touchscreen shall be a resistive touch 7" inch WVGA TFT LCD with 800x480 resolution.

2.6 OPERATOR SCREENS

- A The Operator Screens shall be constructed so that every main screen is within one click of each other. A common navigation bar should be available so that any screen can be accessed from another screen without the need to return to a main menu. The Screen Navigation buttons shall be graphical in nature and indicate visually whether the screen is available to be selected, is unselected, or is selected.
- B The operator screens shall have visual indication of new and active alarms as well as the number of active alarms on every screen. The active alarm log screen shall be within one click from any other screen.
- C Operator Help Screens shall be available on every screen with screen specific content.
- D The Security Log-in/Log out screens shall be available from every screen.
- E The current System Operating Mode shall be displayed on every screen.
- F One-line Diagram: The One-line Diagram shall display graphical indication of all Power System components monitored by the Load Control Module, including:
- G Generator State (Running, Not Running)

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1. Generator Mode (Auto, Manual, Start Pending, Running, Cooldown, Load Demand Stop)
 2. Generator Fault (Warning, De-rate, Shutdown)
 3. Breaker States (Open, Closed)
 4. All Loads assigned to the Load/Add shed sequence shall display the levels to which the load is assigned
 5. Bus Status (Hot, Cold)
 6. Automatic Transfer Switches shall show status of the switch as well as the source status when available.
 7. The Power System device names shall be field editable to suit customer specific device names and shall not require programming software to do so.
 8. Average Voltage and Power for each source shall be displayed.
- H The Generator Summary Screen shall display generator state, status, and all engine and alternator parameters including at a minimum the following:
1. Generator Control Switch Position
 2. Generator State
 - a. Stopped
 - b. Start Pending
 - c. Warmup at Idle
 - d. Running
 - e. Cool down at rated
 - f. Cool down at idle
 - g. Generator Common Warning
 - h. Generator Shutdown
 3. Load Demand Stop
 4. Circuit Breaker Position
 - a. Open, Closed
 5. Engine Data
 - a. Engine Speed
 - b. Oil Pressure
 - c. Coolant Temperature
 - d. Battery Voltage
 - e. Engine Runtime
 - f. Number of Starts
 - g. Kilowatt Hours
 - h. Fuel Rate
 - i. Total Fuel Used
 6. Alternator Data
 - a. Line to Line Voltage
 - b. Line to Neutral Voltage
 - c. Current
 - d. Frequency
 - e. Power Factor
 - f. Total kW
 - g. Percent kW
 7. Total kVA

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- a. Total kVAR
- 8. Paralleling Bus Data
 - a. Line to Neutral Voltage
 - b. Line to Line Voltage
 - c. Frequency
- 9. Annunciator Points
 - a. Common Alarm
 - b. Genset Supplying Load
 - c. Genset Running
 - d. Not in Auto
 - e. High Battery Voltage
 - f. Low Battery Voltage
 - g. Charger AC Failure
 - h. Failed to Start
 - i. Low Coolant Temperature
 - j. Pre High Engine Temperature
 - k. High Engine Temperature
 - l. Pre Low Oil Pressure
 - m. Over Speed
 - n. Low Coolant Level
 - o. Low Fuel Level
- 10. Analog Gauges shall be available and the gauge range shall be field adjustable without additional programming software.
 - a. Power
 - b. Average Voltage Line to Line
 - c. Average Current
 - d. Frequency
- 11. Oil Pressure
 - a. Coolant Temperature
 - b. Engine Speed
 - c. Battery Voltage

I Metering Screen

- 1. The metering screen shall display system metering data at a minimum for all source breakers. The metering shall be a minimum of 1% accurate for voltage and current measurements.
- 2. The following data shall be displayed.
 - a. Voltage Line to Line (Phase)
 - b. Voltage Line to Line (Average)
- 3. Voltage Line to Neutral (Phase)
 - a. Voltage Line to Neutral (Average)
 - b. Current (Phase)
 - c. Current (Average)
 - d. Frequency
 - e. Real Power (Phase)
 - f. Real Power (Average)

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4. Reactive Power (Phase)
 - a. Reactive Power (Average)
 - b. Apparent Power (Phase)
 - c. Apparent Power (Average)
 - d. Power Factor (Average)
 - e. KW Hours Import (Total)

2.7 KW HOURS EXPORT (TOTAL)

- a. KVAR Hours Import (Total)
- b. KVAR Hours Export (Total)
2. Analog Gauges should be available for the following parameters. The range shall be field adjustable for min and max. The gauges shall be available in two sizes.
 - a. Real Power (kW)
 - b. Average Voltage Line to Line
 - c. Average Current
 - d. Frequency

B Load Control Screen

1. The Load Control Screen shall allow for load level configuration for each load to be shed. Each load should be able to be assigned to a configurable load add and load shed level.
2. The Shed levels should be allowed to be automatically assigned according to the order of the assigned add level, or if desired be operator customized.
3. Each Load shall be able to have a field configurable name that corresponds to the name on the One-line diagram. Programming software should not be required to change the load name.
4. The Load Control Screen shall show the status of each Load Level as follows:
 - a. Added
 - b. Shed
 - c. Restored
 - d. Generator Bus Metering Shall be displayed on the Load Control Screen.
 - e. Manual Add/Shed control of each load level shall be available.

C Event Log Screen

1. The Event Log Screen shall log all events in the system. In general this should be any change in the system that does not require operator intervention or acknowledgement.
2. The Event Log shall log all state changes for Security Log, System Events, Breakers, Generators, and ATS as follows:
 - a. Generator
 - 1) The generator is warming up at idle
 - 2) The generator is running
 - 3) The generator is cooling down at rated speedidle
 - 4) The generator is cooling down at idle
 - 5) The generator has stopped
 - b. Breaker

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- 1) The circuit breaker is closed
 - 2) The circuit breaker is open
 - c. ATS
 - 1) The ATS is connected to normal
 - 2) The ATS is connected to Emergency
 - 3) The ATS is in neutral position
 - 4) The ATS is connected to both normal and emergency source (Closed Transition ATS only)
 - d. Security
 - 1) User Log on
 - 2) User log off
- D Current Alarm Screen
 - 1. The Current Alarm Screen shall display all currently active or unacknowledged alarms
 - 2. The alarm shall be time and date stamped.
 - 3. The Load Control system shall log at a minimum the following alarms:
 - a. Generator Alarms
 - 1) Communication Failure
 - 2) Common Alarm
 - 3) Not in auto
 - b. Feeder Breaker Alarms
 - 1) Trip
 - c. Load Control Alarms
 - 1) Overload Alarm
 - 2) Load Shed Level (one alarm per shed level)
 - d. Communication Alarms
 - 1) IO Device warning
 - 2) IO Device failure
 - 3) IO Device Communication alarm
 - 4) PLC to touchscreen communication failure
- E Security
 - 1. The Security of the Operator Screen should have levels of security that allow different access for:
 - a. View only
 - b. Operators and Managers
 - c. Technicians
 - d. Each user's log in activity shall be recorded in the event log.
 - e. The security system should have an auto logout period when there is no activity. This time delay should be field adjustable.
- F Integrity Checks
 - 1. All operator and factory settings shall have integrity bounds checks built in to ensure that an only a valid entry is allowed.

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G Building Management Interface

1. The building management interface shall be Modbus TCP/IP

2.8 INTERNAL CONTROLS FOR THE LOAD CONTROL MODULE SHOULD BE COMPRISED OF THE FOLLOWING

A Expected Monitoring I/O

1. The Load Control Module shall monitor the following breaker status at a minimum.
 - a. Aux A contact.
 - b. Tripped Status
2. The Load Control Module shall monitor the following generator status points through hard wired inputs at a minimum.
 - a. Ready to Load (90% rated voltage and frequency)
 - b. Load Dump/Load Shed

B The Load Control System shall use circuit protection for control circuitry that indicates when the protective device needs to be reset or replaced.

C The Load Control System shall allow for all field wiring to be landed on dedicated terminal blocks. The terminal blocks shall be rated to be capable of the largest required wire gauge that may be required for field wiring.

D All Control Relays in the Load Control Module shall have LED indicators.

E The Load Control System 24VDC bus for control power shall be derived from a "best battery". The "best battery" shall combine the 24VDC battery supplies from each generator

F The Load Control System shall include a 24VDC UPS capable of supplying the entire cabinet's power requirements during starter dip of the engine generators, as well as be able to supply the power requirements in the case of a failure of all generator batteries. The UPS system shall be capable of supplying the Load Control System power for at least 10 minutes during a power outage before additional charging is required.

G SEQUENCE OF OPERATION

1. System Modes
 - a. Normal Standby Conditions
 - b. Generator set breakers are open and the generator sets are not running.
 - 1) All generator sets are in Auto at each generator set PCC.
 - 2) Feeder breakers are in the open position.
 - 3) The Load Control Module (LCM) System Mode is set to Standby.
 - c. Loss of Normal Source
 - 1) The generator sets receive a remote start signal
 - 2) The generator Start Delay within the generator control starts timing and expires

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- 3) The generator sets start automatically and independently, and accelerate to rated voltage and frequency
 - 4) The first generator set closes to the bus as directed by First Start System
 - 5) The normal load add sequence starts as described in Normal Load Control
 - 6) The remaining generator sets synchronize to the Gen bus and close their respective generator set breakers when synchronization conditions are met within their PCC's
 - 7) The Generator sets proportionally share load on the Genbus if there is any load on the Genbus
 - 8) Masterless Load Demand operates if it is enabled
2. Return of Normal Source
- 1) The generator sets detect the removal of the remote start signal.
 - 2) The PCC on each generator set opens its generator set breaker.
 - 3) All feeder breakers not assigned to Load Shed Level 0 are commanded to open.
 - 4) The generator sets run in cooldown mode and then stop.
 - 5) The system returns to Normal Standby Conditions.
3. Normal Load Control
- a. Load Control Levels
- 1) Normal load control uses two sets of levels for control. Each load is assigned to a load add (0-8) and shed level (0-7). A load add or shed level can have one or more loads assigned to it. A single load may only have 1 level for add and 1 level for shed assigned to it.
 - 2) A load assigned to Load Add Level 0 is not part of the Load Add sequence and is assigned to Load Shed Level 0. A load assigned to an add level of 0 is forced to have a shed level of 0. This is useful for future loads.
 - 3) Add levels are used to control the load stepping onto the generator sets while they are connecting to the Genbus. Level 1 is the first load to add. Level 2 is the second load to add, and so forth up to the total number of load add levels assigned in the system.
 - 4) Shed levels are used to handle load removal from the Genbus if the DMC receives a Load Dump signal from the generator sets. Level 1 is the first load to shed. Level 2 is the second load to shed, and so forth up to the total number of load shed levels in the system. A shed level of 0 is used for critical loads that should never shed. Because a level 0 load never sheds, it cannot have an add level higher than 1 since it is assumed to be on the Genbus when the generator sets connect.
 - 5) Shed level assignment can be done automatically by the DMC (if used) based on the load add level or can be user defined. When the shed sequence is automatically determined, the loads shed in the reverse order that they were added. When user defined, the restrictions stated above for shed level 0 still apply.
- b. Load Control Sizing

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- 1) When sizing system loads to generator sets, load(s) assigned to Load Add Level 1 should not exceed the kW capacity of the smallest generator set in the system (if paralleling). Loads assigned to Load Add Level 2 should not exceed the kW capacity of the smallest two generator sets in the system (if paralleling). This philosophy should continue for all of the generator sets in the system until the Required Online Capacity is reached. This is important when the generator sets in the system are not the same size. Starting with the smallest generator set takes into account the worst case sizing scenario.
- c. Load Control Timing
 - 1) The Genbus has two time delays for controlling the load.
 - (a) Genbus Delay - The amount of time that must expire before adding the next load add level. The delay ensures that loads do not add too rapidly if the generator sets parallel with each other on the Genbus too quickly.
 - (b) Shed Delay – The amount of time that must expire before shedding the next load shed level. The delay allows the system to stabilize before shedding load too rapidly and possibly dropping more load than required to clear an overload condition.
- d. Load Add Sequence
 - 1) Each load is assigned a load add level.
 - 2) When the first generator set connects to the Genbus, all loads assigned to Load Add Level 1 are commanded to add.
 - 3) The Genbus Delay starts timing.
 - 4) When the second generator set connects to the Genbus and the Genbus Delay has expired, all loads assigned to Load Add Level 2 are commanded to add.
 - 5) The Genbus Delay resets and starts timing for the newly added load add Level.
 - 6) This sequence continues until the Required Online Capacity for the Genbus is met or when all existing generator sets connect to the Genbus. Any remaining levels are added separated by the Genbus Delay.
 - 7) In the event that the Required Online Capacity for the Genbus is not met and not all existing generator sets connect to the Genbus, the LCM only adds load add levels equal to the number of generator sets online. Any further load add levels need to be added using the manual commands on the Load Control screen. The operator is responsible for verifying that enough capacity exists to add a specific level. Levels do not need to be added in order.
 - 8) If an overload condition occurs for any reason, load adding stops and the system starts the load shed sequence.
- e. Load Shed Sequence
 - 1) Each load is assigned a load shed level.
 - 2) One or more connected generator sets sends a Load Dump signal to the LCM.

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- 3) Upon detection of an overload (Load Dump) signal from any generator set, the smallest non-zero load shed level that is connected to the Genbus is instantly turned on. Typically, Load Shed Level 1. It may not be shed level 1 if the load add did not complete before the overload condition occurred or if Load Shed Level 1 was not assigned to a load.
 - 4) The Shed Delay starts timing.
 - 5) When the Shed Delay expires, the LCM continues to monitor the Load Dump signal. If the signal is still present, the next load shed level that is connected to the Genbus is turned on. Typically, Load Shed Level 2.
 - 6) The Shed Delay resets and starts timing again for the next load shed level.
 - 7) The sequence continues until all load shed levels that were connected to the Genbus turn on (except for Load Shed Level 0) or the LCM detects that the Load Dump signal has been removed by the generator sets.
 - 8) When the overload condition is no longer active, the operator resets the overload alarm and restores load shed levels on the Load Control screen. Restoration of load shed levels does not need to be done in order. Loads that have been shed cannot be restored until the overload alarm is cleared.
 - 9) As long as the system is on generator set source, there is no automatic restore for levels that have been shed. They must be manually restored by the operator.
 - 10) If a restored level causes an overload condition, restoration of levels is stopped and the load shed sequence starts again.
- f. Manual Operation
- 1) When System mode 'Off' is selected at the HMI, no automatic operations are performed by the LMC. Any breaker open/close must be initiated by the operator from the breaker control switches.

- H Remote Emergency-Stop Switch: Flush; wall mounted, In weatherproof enclosure, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.9 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A Generator Circuit Breaker: EO/Paralleling Breaker 2500A/2250AT; 100 percent rated; complying with UL 489.
1. Tripping Characteristics: Adjustable long-time, short-time delay and instantaneous.
 - a. Provide bypass switch to defeat instantaneous trip.
 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 4. Mounting: Adjacent to or integrated with control and monitoring panel.
- B Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

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2.10 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A Comply with NEMA MG 1.
- B Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C Electrical Insulation: Class H or Class F.
- D Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F Enclosure: Drip-proof.
- G Instrument Transformers: Mounted within generator enclosure.
- H Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I Windings: 0.7333 pitch stator winding and fully linked amortisseur winding.
- J Sub-transient Reactance: 12 percent, maximum.

2.11 MOTORS

- A General requirements for motors are specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven loads will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

2.12 VIBRATION ISOLATION DEVICES

- A Spring type Isolators: Freestanding, steel, open-spring isolators as required by the manufacturer.

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1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.13 OUTDOOR ENCLOSURE

- A Housing: Description: Vandal-resistant, weatherproof, non-walk-in type, aluminum housing; wind resistant up to 100 mph (160 km/h). Instruments and control shall be mounted within enclosure. Acoustically rated, Level 3 (70dBa @ 23 feet). Enclosure with the following features:
1. Hinged Doors: With padlocking provisions.
 2. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
- B For non-walk-in type enclosures where access to controls and maintainable items require use of a ladder, a permanent service platform shall be provided which surrounds the enclosure on three sides, complete with access ladder and railings that meets the standards of OSHA 3124 - Stairways and Ladders.
1. The platform shall be manufactured by Generator Systems Support or approved equal.
 2. The platform shall be cantilever supported off of the engine generator sub-base with formed aluminum frame, structural members, toe plates, railing posts, rails and floor assemblies, Platform shall be of the U construction with 2 "walk" assemblies (outside of all generator set service doors), connected together with a "rear" platform at the control panel end. A "ship's ladder" shall be used to access the platform.
 3. No connection to the sub-base tank is permitted but rather all connections shall be through the engine base.
 4. Platform shall provide for 180 degree "full swing opening" of all side service doors and at least 135 degree opening of the rear control panel door.
 5. The platform frame, railings and all components shall be of .125 gauge formed aluminum.
- C Muffler Location: Within enclosure.
- D FOR UNITS 750 KW AND LARGER Provide 100 Amp, 208/120 V, 3 phase , 4 wire, load center with main breaker and sufficient branch circuit breakers for all generator accessories plus two spare 20A/1P. Provide transformer of sufficient size to transform from 480V 3 phase 4wire to 208/120V 3 phase 4 wire for panel.

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- E Interior Lights with Switch: Factory-wired, vapor-proof-type fluorescent fixtures within housing; arranged to illuminate controls and accessible interior. Provide switch at all access doors. Electrical connection to load center.
- F Convenience Outlets: Factory wired, GFCI, four required, electrical connection to load center.
- G Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
- H Louvers: motor operated cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow, exterior dust, birds, and rodents.

2.14 FINISHES

- A Outdoor Enclosures and Components: As selected by Architect from Manufacturer's standard finishes.

2.15 SOURCE QUALITY CONTROL

- A Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 - 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 - 2. Full load run.
 - 3. Maximum power.
 - 4. Voltage regulation.
 - 5. Transient and steady-state governing.
 - 6. Single-step load pickup.
 - 7. Safety shutdown.
 - 8. Provide 14 days' advance notice of tests and opportunity for observation of tests by the Owner's representative.
 - 9. Report factory test results within 10 days of completion of test.

PART 3 EXECUTION

3.1 EXAMINATION

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- A Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C Install outdoor engine generators on a concrete pad designed by a Structural Engineer retained by the Contractor and coordinated with the manufacturer for anchor insert locations.
- D Install service platforms for outdoor non-walk- in enclosures.
- E Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
- F Coordinate installation of fuel oil piping from main storage tank to generators and all associated work with Division 23 Contractor. This Contractor shall be responsible to provide a complete working system.
- G Install remote Annunciator(s) in building security command center or as indicated. Provide all interconnecting wiring.

3.3 CONNECTIONS

- A Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

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- C Tighten electrical joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values using a calibrated torque wrench. Provide a list of all torqued connections and values.
- D Provide all interconnecting wiring between the generator and transfer switches as required for proper operation of system, provide a start circuit from each transfer switch.
- E Provide control circuits from the fire pump controller to start the engine-generator.
- F Furnish and install wiring from communications devices to Owner's data collection and control network.
- G Furnish and install control and power wiring for remote fuel oil pumping systems. Coordinate with Mechanical Contractor for exact requirements.
- H Furnish and install all miscellaneous control and power wiring as required for a complete and functioning system that meets all Owner, AHJ, and Code requirements.
- I Furnish and install controls as required to allow the ability for the BMS to provide load shedding thru ATS.

3.4 IDENTIFICATION

- A Identify system components according to Division 26 Section "Identification for Electrical Systems."

3.5 ADJUSTING

- A Set engine-generator circuit breaker and relay protective functions per Division 26 Section "ELECTRICAL SYSTEM STUDIES."

3.6 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

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- C This Contractor is responsible for the following tests and inspections:
1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 3. The diesel generator set shall operate under full load conditions for a minimum of four (4) hours. The generator set shall maintain rated voltage and rated frequency per Specifications for the duration of the full load test. Voltage, amperage and frequency measurements, as well as engine gauge and monitor points, shall be recorded at 15 minute intervals. All doors of the weatherproof housing shall remain closed during testing.
 4. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 6. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 7. Exhaust Emissions Test: Comply with applicable government test criteria.
 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- D Coordinate tests with tests for transfer switches and run them concurrently.
- E Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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- H Remove and replace malfunctioning units and retest as specified above.
- I Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J This Contractor shall top off all fuel tanks at completion of testing. Fill all engine fluids to levels as recommended by manufacturer.
- K Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations.
- L Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

3.7 DEMONSTRATION

- A Engage a factory-authorized service representative to train Owner maintenance personnel to adjust, operate, and maintain packaged engine generators. Provide two - 8 hour sessions. Conduct this training concurrently with ATS training, refer to Section 263600.

END OF SECTION 263213

END OF SECTION 263213

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SECTION 263353
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Charger/rectifier units.
- B Inverter units.
- C Batteries.

1.2 RELATED REQUIREMENTS

- A Section 253629 - Integrated Automation UPS monitors
- B Section 260529 - Hangers and Supports for Electrical Systems
- C Section 260548 - Vibration Controls for Electrical Systems.

1.3 REFERENCE STANDARDS

- A IEEE 519 - IEEE Standard for Harmonic Control in Electric Power Systems; 2022.
- B NEMA PE 1 - Uninterruptible Power Systems (UPS) - Specification and Performance Verification; 2012 (Reaffirmed 2017).
- C NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- D NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 SUBMITTALS

- A See Section 013000 Administrative Requirements for submittal procedures.

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- B Shop Drawings: Indicate electrical characteristics and connection requirements. Provide battery rack dimensions; battery type, size, dimensions, and weight; detailed equipment outlines, weight, and dimensions; location of conduit entry and exit; single-line diagram indicating metering, control, and external wiring requirements; heat rejection and air flow requirements.
- C Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.

1.5 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.
- B Products: Listed, classified, and labeled as suitable for the purpose intended.

1.6 DELIVERY, STORAGE, AND HANDLING

- A Protect equipment from extreme temperature and humidity by storing in a conditioned space.
- B Protect equipment from dust and debris by wrapping unit in dusttight cover and storing away from construction activity.
- C Deliver batteries no sooner than 7 days before charging.

1.7 FIELD CONDITIONS

- A Do not store or install unless temperature is maintained between 32 degrees F (0 degrees C) and 104 degrees F (40 degrees C), at a relative humidity less than 95 percent (non-condensing).
- B Maintain conditions during and after installation of products.

1.8 WARRANTY

- A See Section 017800 - Closeout Submittals for additional warranty requirements.
- B Provide 2 year warranty including coverage for batteries.

PART 2 PRODUCTS

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2.1 MANUFACTURERS

- A Uninterruptible Power Supply (UPS) System:
1. Liebert Corporation: www.vertiv.com.
 2. ABB: Electrification.us.abb.com
 3. Eaton Corporation: www.eaton.com/#sle.
 4. Mitsubishi Electric Power Products, Inc: www.meppi.com.
 5. Schneider Electric: www.se.com/#sle.
 6. Toshiba Corporation: www.toshiba.com/#sle.

2.2 UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEMS

- A System Configuration: Non-redundant type with reverse transfer. Designed for capacity expansion by addition of parallel modules in field with minimum downtime.
- B Components:
1. Rectifier/charger to maintain battery charge and to provide input to inverter when utility power is available.
 2. Inverter to provide power to load during normal operation.
 3. Static switch to transfer load automatically and without disturbance between inverter and utility power.
 4. Manual switch to bypass static switch for maintenance.
 5. Input and output isolation transformers and filters to provide appropriate isolation and disturbance attenuation.
 6. Monitors, sensors, and control circuits.
- C Design Standards: IEEE 519 and NEMA PE 1.

2.3 SYSTEM RATINGS AND OPERATING CHARACTERISTICS

- A System Continuous Rating: As indicated on drawings, over entire battery voltage range at specified power factor. Maintain output voltage within specified limits at any load from full load to no-load.
- B Battery Capacity: Capable of operating at full load for 10 minutes
- C Voltage Rating: As indicated on drawing
- D Input Voltage Operating Range: Plus or minus 10 percent.
- E Input Frequency Operating Range: 60 Hz. Plus or minus 3 Hz.

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- F Input Current Limit: Adjustable to maximum of 125 percent of that required to operate at full load with battery bank on float charge.
- G Short-Circuit Current Rating (SCCR): 65 kA.
- H Current Walk-in: 25 to 100 percent in fifteen seconds.
- I UPS Power Factor Over Full Range of Loads and Input Voltages: 74 to 100 percent, lagging.
- J Harmonic Distortion of Input Current Wave Form: 5 percent maximum at full load.
- K Output Voltage regulation:
 - 1. Plus or minus 3 percent for balanced load, full range of DC input and no load to full load variations.
- L Output Voltage Adjustment: Adjustable.
- M Output Free Running Frequency: 60 Hz Plus or minus 0.5 percent.
- N Frequency Adjustment: Adjustable.
- O Output Harmonic Distortion: Maximum 5 percent rms total harmonic distortion (THD) and maximum 3 percent any single harmonic, at rated frequency and voltage, from 10 percent load to full load and over battery voltage range, measured into a linear load.
- P Voltage Transient Response for Application of 0 to 50 Percent, 50 to 100 Percent, 100 to 50 Percent, and 50 to 0 Percent Step Loads, and Transfer To and From Bypass Line:
 - 1. Plus 8, minus 10 percent for maximum of 8.3 milliseconds.
 - 2. Plus or minus 5 percent for maximum of 25 milliseconds.
 - 3. Plus or minus 3 percent for maximum of 50 milliseconds.
 - 4. Recovery to steady state within 100 milliseconds after any out-of-tolerance variation.
- Q Phase Displacement:
 - 1. 120 plus or minus 1 degrees for balanced loads.
 - 2. 120 plus or minus 4 degrees for 50 percent unbalanced loads.
- R Three-phase Overload Ratings:
 - 1. 1000 percent for 5 cycles; via static switch.
 - 2. 150 percent for 10 seconds.
 - 3. 125 percent for 10 minutes.

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- S Output Current Limit: 150 percent of rated output current.
- T Voltage Unbalance: 3 percent maximum line-line with 100 percent load unbalance.
- U Efficiency: 96 to 99 percent. Measure efficiency of unit including battery and isolation transformer losses.

2.4 DESIGN

- A Inverter Type: Pulse-width modulated.
- B Rectifier/Charger Capacity: Sufficient to supply full load to inverter while recharging fully-discharged battery to 95 percent of full capacity in four hours or less; and within the input current limits specified.
- C Provide means for on-line testing of UPS, including test points to allow adjusting and servicing. Provide means for testing static switch while load is bypassed to utility.
- D Mean Time Between Failures: 60,000 hours, minimum.
- E Cooling: Natural convection.
- F Forced Air Cooled Unit: Provide with redundant cooling so that failure of any one cabinet cooling fan or fan circuit will not affect continued operation at full load and ambient temperature of 77 degrees F (25 degrees C) or lower.
- G Operate battery floating, isolated from the UPS AC input and AC output. The battery may be resistance grounded through 5,000 to 10,000 ohms for the purpose of ground fault sensing.
- H Do not use continuous moving parts or electron tubes. Accomplish power switching using semiconductor devices.
- I Use front-panel removable plug-in control modules.

2.5 FABRICATION

- A Electroplate brackets and securing hardware with corrosion resistant material. Secure bolts, studs and nuts with lock washers.
- B Identify internal wiring at each end of conductor. Provide cabinet grounding lug.

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- C Conversion Equipment Enclosure: NEMA EN 10250, Type 1 enclosure allowing access from front for servicing adjustments and connections. Access through hinged door equipped with tumbler lock and latch handle. Equip cabinet for fork truck lifting.
- D Equip air inlet with permanent type filters and pressurize cabinet, or use gaskets around door and panel openings to prevent entry of dirt.

2.6 BATTERY

- A Storage Battery: Lithium heavy duty industrial battery, designed for auxiliary power service. Provide battery with impact resistant plastic case. Provide cells with explosion proof vents, clear containers, and ample space for plate growth without stressing container and cover.
- B Ampere-Hour Rating: Sufficient to supply direct current to inverter for outage period specified, with inverter operating at full rated output, to a discharge limit of not less than 1.65 volts per cell.
- C Battery Racks: Maximum of three-tier, all steel construction, with plastic insulating rails at all points of contact with the battery case. Paint racks with acid resistant paint.

2.7 CONTROLS AND INDICATORS

- A Controls:
 - 1. AC input circuit breaker.
 - 2. Inverter operate switch to initiate inverter operation.
 - 3. Inverter standby switch to cause inverter to cease operation
 - 4. Static switch transfer switch to permit manual actuation of static transfer switch.
 - 5. Static switch lock-out switch to inhibit automatic retransfer of load to inverter.
 - 6. Battery charge timer.
 - 7. Indicator test switch.
 - 8. Static switch preferred input circuit breaker
 - 9. Static switch output circuit breaker.
 - 10. Static switch bypass circuit breaker.
 - 11. Controls for maintenance bypass switch.
- B Indicators:
 - 1. Inverter synchronized to utility.
 - 2. Load connected to utility.
 - 3. Static transfer switch inhibited.
 - 4. High/low DC voltage.
 - 5. Overtemperature.
 - 6. Inverter output overload.

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- C Meters: Use 1 percent accuracy meters to indicate the following:
 - 1. Rectifier/charger DC voltage and current.
 - 2. Utility, inverter output, and load AC voltage.
 - 3. Load AC current.
 - 4. Inverter output and utility frequency.
 - 5. UPS output watts.

- D Wall-mounted Alarm Panel: Surface mounted annunciator panel with the following monitoring and alarm functions:
 - 1. Utility power available.
 - 2. Utility bypass power available.
 - 3. Inverter output available.
 - 4. Inverter synchronized to utility.
 - 5. Load connected to inverter output.
 - 6. Load connected to utility bypass power (alarm).
 - 7. Static transfer switch inhibited (alarm).
 - 8. High/low DC voltage (alarm).
 - 9. Overtemperature (alarm).
 - 10. Inverter output overload (alarm).
 - 11. Audible alarm (sounds when any of the above alarm conditions occur).
 - 12. Alarm/indicator silence/test switch.

- E External Connectivity: Provide remote interface connection per Section 253629 requirements.

- F Provide connectivity to BMS system as required

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with manufacturer's instructions.

- B Provide required support and attachment in accordance with Section 260529.

- C Provide required seismic controls in accordance with Section 260548.

3.2 FIELD QUALITY CONTROL

- A See Section 014000 - NOT OEC EDITED - Quality Requirements, for additional requirements.

- B Provide the services of the manufacturer's field technician to supervise adjustments, final connections, and system testing.

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- C Verify specification performance criteria.
- D Measure battery discharge and recharge times.
- E Simulate fault in each system component and utility power.
- F Operate unit at 77 degrees F (25 degrees C) for eight hours.
- G Perform other tests as recommended by manufacturer.
- H Provide burn in testing for static UPS system

3.3 CLOSEOUT ACTIVITIES

- A See Section 017800 - Closeout Submittals017800 - Closeout Submittals, for closeout submittals.
- B See Section 017900 Demonstration and Train 017900 - NOT OEC EDITED - Demonstration and Training, for additional requirements.
- C Demonstrate operation uninterruptible power supply by simulating an outage.
- D Training: Provide hours of instruction each for two persons.
 - 1. Instruction to be conducted at project site with manufacturer's representative.
 - 2. Include travel and living expenses for Owner personnel.

3.4 MAINTENANCE

- A See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B Provide a separate maintenance contract for specified maintenance service.
- C Provide service and maintenance of uninterruptible power supply for one year from Date of Substantial Completion.
- D Include all costs, including labor, parts, and travel.

END OF SECTION 263353

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SECTION 263600
TRANSFER SWITCHES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic Transfer Switches (ATS).
 - 2. Closed Transition Transfer Switches (CTTS).
 - 3. Bypass/Isolation switches.
- B Related Sections include the following:
 - 1. Division 26 Section "Engine Generators" for interfacing with Emergency Power Systems.

1.3 SUBMITTALS

- A Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, accessories and catalog data sheets.
- B Shop Drawings: "Typical" drawings are not acceptable. Provide project specific drawings for each transfer switch. Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Wiring Diagrams: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C Qualification Data: For manufacturer.
- D Field quality-control test reports.

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- E Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Features and operating sequences, both automatic and manual.
 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

- A Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B Source Limitations: Obtain automatic transfer switches and bypass/isolation switches through one source from a single manufacturer.
- C Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E Comply with NEMA ICS 1.
- F Comply with NFPA 70.
- G Comply with NFPA 110.
- H Comply with UL 1008 unless requirements of these Specifications are stricter.
- I Comply with Owner Design Standards.

1.5 WARRANTY

- A The automatic transfer switch shall be provided with a five year warranty, covering all parts, labor, travel and expenses during the first two years, followed by three years of replacement parts coverage. Warranty shall commence on startup or six months from date of shipment, whichever occurs first. Warranty shall not be dependent upon customer purchase of additional equipment or preventive maintenance contracts.

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1.6 COORDINATION

- A Coordinate communication module package with monitoring equipment for successful transmission and remote readout of remote monitoring data specified in this Section.
- B Floor mounted switches: Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Provide Transfer Switch products of the same manufacturer as that specified for the paralleling switchgear.
- B Provide products by one of the following
 1. Catapillar
 2. Russelectric
 3. Cummins/ Onan
 4. Kohler
 5. Generac
- C Basis of Design: Transfer switches shown on Drawings are based on equipment by the underlined manufacturer listed first above.
 1. Other approved manufacturers, including those approved by substitution requests prior to bid award, are allowed on condition that the contractor provides accessories and added labor as needed to meet requirements of Contract Documents at no added cost to owner.
 2. Equipment ordered, shipped, and/or installed (a) using a manufacturer not approved prior to award of bid, or (b) without owner-approved shop drawings, or (c) without owner-approved power system studies per Specification Section 26 05 73 is subject to replacement at no cost to owner.
 3. In addition, Contractor is responsible for supplying equipment that fits in the available space as shown on Contract Documents, including code and manufacturer required working and service clearances around the equipment as well as clearance and pathways for future removal and replacement of equipment as shown on Drawings.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

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- B Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
1. A color, ¼ VGA minimum, graphical displays shall be provided for viewing data and setting operational parameters. Parameters shall also be available for viewing remotely and limited control through a front accessible USB communications port with keypad.
 2. All control components and wiring shall be front accessible. All control wires shall be multi-conductor 18 gauge 600-volt SIS switchboard type point to point harness. All control wire terminations shall be identified with tubular sleeve-type markers.
 3. The Controller shall provide high intensity LED's for the following:
 - a. Source Availability - Indicates the source voltage and frequency are within pre-set parameters.
 - b. Source Connected - Indicates the source main contacts closed and the load being served from the source.
 - c. XFER Inhibit - Indicates that the ATS is being inhibited from automatic operation to the unconnected source.
 - d. Alarm: Indicates an alarm condition is active.
 - e. TD Active: Indicates that a transfer switch time delay is actively timing.
 4. For ease of navigation, the display shall include the following:
 - a. Soft Keys – Change function based on user location in the menu structure.
 - b. Dedicated Navigational Keys – Home, Scroll Up, End, Escape and Enter.
 - c. Dedicated Pushbuttons for Alarm Reset, Test, Control and Information.
- C Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- D Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- E The automatic transfer switch shall be capable of transferring successfully in either direction with 70% of rated voltage applied to the switch terminals.
- F Switches shall be 3 pole for 3 wire circuits and four-pole for 4 wire circuits as indicated on the drawings. A true four pole switch shall be supplied, with all four poles mounted on a common shaft. The entire fourth pole assembly, including contacts, arc chutes, etc. shall be identical to the other power poles. The fourth pole shall be switched simultaneously with, and by the same mechanism as, the main power poles. The short circuit rating of the fourth pole shall be identical to the ratings of the main power poles. The complete assembly shall be factory tested to ensure proper operation and compliance with the specifications requirements.
- G Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 2. Switch Action: Double throw; mechanically held in both directions.

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3. Contacts: Silver composition or silver alloy for load-current switching. All automatic transfer-switch shall have separate arcing contacts.

- H Tested Fault-Current Closing and Withstand Ratings: The transfer switch shall be UL listed in accordance with UL 1008 for 3 and 30 cycle close and withstand ratings for duty imposed by protective devices at installation locations in Project under the fault conditions indicated. Switches that are not tested and labeled by UL for 3 and 30 cycle ratings are not acceptable. In accordance with UL-1008, after completion of the short time closing and withstand testing, the same sample shall successfully pass the Temperature Test and the Dielectric Voltage-Withstand Test to verify the ability of the ATS to carry full rated current after completing the short time tests. The minimum UL listed close and withstand ratings at 480 VAC shall be as follows:

Size Amps	3 Cycle	30 Cycle	Current Limiting Fuses
100 – 400	42 Ka	30 Ka	200,000 a
600 – 800	65 Ka	42 Ka	200,000 a
1000 – 1200	85 Ka	65 Ka	200,000 a
1600 – 3000	100 Ka	85 Ka	200,000 a

- I Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with annunciator.
- J Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- K Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, or in a switchboard assembly in accordance with UL 891, unless otherwise indicated. Enclosures shall be designed and constructed to allow installation and access as shown on drawings.
1. ATS/Bypass enclosure shall be constructed so that personnel are protected from energized bypass-isolation components during automatic transfer switch maintenance.
 2. Automatic transfer switch components shall be removable without disconnecting external source or load power conductors.
 3. Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal.
 4. ATS/Bypass switches shall be operable from a dead-front location.
 5. Permanently attach wiring diagrams and maintenance instructions on the inside of enclosure door in a mounting designed to hold the data.

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- L Switches shall be equipped with mechanical type lugs. The lugs shall be furnished with the ATS and the UL listing of the switch shall not be compromised.
- M Communications Modules:
 - 1. The Controller shall be capable of supporting Ethernet 10/100MBit communications via an internally mounted and self powered communications card. Include an RJ45 network connector. Ethernet communications shall be MODBUS protocol.
 - 2. ATS shall be capable of connecting to BMS system with Backnet IP
- N Power quality metering:
 - 1. Digital power quality meter on load circuit wired to shorting type terminal block. Meter shall be Power-Logic PM5563 or equal.
- O Load shedding
 - 1. The Chiller ATS's shall be connected to manually load shed the chiller(s) from the normal power system..

2.3 AUTOMATIC TRANSFER SWITCHES

- A Comply with Level 1 equipment according to NFPA 110.
- B The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in position in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Main contacts on all size switches shall be segmented, and shall have separate arcing contacts with magnetic blowouts for positive arc-quenching and maximum contact life.
- C Switching Arrangement: The automatic transfer switch shall be double throw, actuated by one or two electrical operators, momentarily energized and connected to the transfer mechanism by a simple over-center type linkage, providing inherent "quick-break", "quick-make" operation when operated electrically or manually.
 - 1. Single operator for Life Safety and Critical branch switches.
 - 2. Dual operator for Mechanical and Equipment Branch switches, and for UPS loads. The adjustable time delay between the opening of the closed contacts and the closing of the open contacts shall allow the loads to be demagnetized before transfer.

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- D Manual Switch Operation: All open transition transfer switches shall be equipped with a safe manual operator designed to prevent injury to operating personnel. The manual operator shall provide the same contact to contact transfer speed as the electrical operator to prevent a flash-over from switching the main contacts slowly. Manual operation shall not require prior disconnection of electrical operators or control wiring, and shall be safe even if the electrical operator becomes energized during manual operation. The manual operator shall be external type, operable through the door of the enclosure. Safe manual transfer shall be possible under all load conditions, either energized or non-energized. The external manual operator is not required on transfer switches equipped with a bypass switch.
- E Automatic Transfer-Switch Features:
1. Programmable Undervoltage and Frequency Sensing for Each Phase of Normal and Emergency Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 70 to 98 percent of nominal, and dropout voltage is adjustable from 72 to 100 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent. Over voltage to pick up at 102 to 110% and drop out at 100 to 108%. Over frequency sensing to pick up at 50.1 to 69.8 Hz and drop out at 50.0 to 69.7 Hz. Under frequency sensing to pick up at 45.0 to 59.9 Hz and drop out at 45.1 to 60 .0 Hz (VFS1,2)
 2. Contact to close on normal source failure to initiate engine start (CES).
 3. Normal status relay (CS1A).
 4. Emergency status relay (CS2A).
 5. Bypass and transfer switch auxiliary contact in parallel with engine start to maintain start signal whenever load is connected to emergency source (CMES).
 6. The controller shall monitor phase rotation of both sources and inhibit transfer if both sources are not the same phase rotation. Source rotation shall be field selectable as either ABC or CBA (PRR).
 7. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for 3 seconds (TDES).
 8. Adjustable Time Delay: transfer to emergency, adjustable 0 – 9999 seconds. Factory set at 3 seconds (TDNPS).
 9. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 105 percent of nominal. Factory set for pickup at 95 percent (VFS2).
 10. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 5 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored (TDPS).
 11. Time delays to control transition time delay on transfer and re-transfer (TDNNP, TDNP). For dual operator and closed transition types only.
 12. Test Switch: Two position maintained toggle type with guard. Simulate normal-source failure (XT1G).
 13. Switch-Position LED Pilot Lights: (LT1, LT2) Indicate source to which load is connected (green for normal, red for emergency).
 14. Bypass switch position: Green LED (LT16) to indicate bypass switch is in bypass to normal position, flashing when ATS is isolated. Red LED (LT17) to indicate bypass switch is in bypass to emergency position.

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15. Provisions to accept customer supplied remote contact closure or 24 VDC signal to initiate load test (LTR).
16. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: (LT3) Amber light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: (LT4) Amber light with nameplate engraved "Emergency Source Available."
17. Unassigned Auxiliary Contacts: Two normally closed, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac (CS1P, CS2P).
18. Unassigned Auxiliary Contacts: Two normally closed, single-pole, double-throw contacts for emergency switch position, rated 10 A at 240-V ac (CS2P).
19. Unassigned Auxiliary Contacts: Two closed, single-pole, double-throw contacts when switch is bypassed to normal and emergency switch positions, rated 10 A at 240-VAC (CB1, CB2).
20. Load Control Relays: The ATSS shall be equipped with separate Block Transfer Relay (BTR) and Load Shed Relay (LSR) for use with 24 volt load control signals from Generator synchronizing switchgear.
21. Provide additional elevator signals on switches connected to emergency equipment branch:
 - a. Additional Form "C" contacts (two) to indicate ATS in Emergency position.
 - b. Form "C" time delay contacts (two) that change state simultaneously 0-3600 seconds before transfer in either direction and revert 0-3600 seconds after transfer is completed.
22. Engine overrun to provide unloaded operation after retransfer to normal (2e), adjustable from 0 – 3600 seconds, factory set at 300 seconds. The transfer switch cool-down timer shall be coordinated with any engine control cool-down timers to avoid excessive unloaded operation.
 - a. Engine-Generator Exerciser: The controller shall include a user configurable exerciser. Exerciser shall be configurable for daily, 7 day, 14 day or 28 day exercise periods, each with (7) programmable events. The exerciser shall also be configurable as a full, 365 day exerciser with up to 24 independent exercise events. Each event shall be configurable for Test with Load and Test without Load. Each event shall include user adjustable start time, date and test duration. All time and date settings shall be stored in non-volatile EEPROM memory. The controller shall include full programmability for daylight savings time.
23. Provide capabilities to interface with and be controlled by the BMS system for load shedding capabilities.
24. All pilot lights shall be LED, push-to-test type.

2.4 CLOSED TRANSITION TRANSFER SWITCHES

- A Where indicated on drawings provide Automatic Closed-Transition Transfer Switches with the following functions and characteristics:
1. Fully automatic make-before-break operation.
 2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.

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3. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
 - a. Initiation occurs without active control of generator.
 - b. Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
 4. Failure of power source serving load initiates automatic break-before-make transfer with adjustable center off time delay on transfer.
- B In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- C Provide a safety signal (Dry contact outputs) for customer-connected alarm and remote breaker tripping through shunt trips on source circuit breakers.
- D The CTTS/BPS shall be UL listed in accordance with UL 1008.

2.5 BYPASS/ISOLATION SWITCHES

- A Comply with requirements for Level 1 equipment according to NFPA 110.
- B Description: Where indicated on drawings provide a two source manual type bypass switch, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. The bypass isolation switch shall provide a safe and convenient means of manually bypassing and isolating the automatic transfer switch, regardless of the condition of position of the automatic transfer switch. The bypass isolation switch shall have the ability to be used as an emergency backup system in the event of a transfer switch failure. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
1. The bypass switch shall be load break design. Bypassing shall be by means of a single, externally operated handle. This handle shall allow direct, one step bypass to either Source 1 or Source 2, regardless of the position of the automatic transfer switch. The bypass isolation switch shall be purely mechanical, and bypass operation shall not be dependent upon any electrical device or interlocks for safety purposes or proper sequencing.
 2. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
 3. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.

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4. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
 5. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
 6. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
 7. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
 8. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
 9. Installation: Enclosure requires front and side access.
- C Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed silver plated copper bus bars; braced for the indicated available short-circuit current.

2.6 SOURCE QUALITY CONTROL

- A Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 EXECUTION

3.1 INSTALLATION

- A Floor-Mounting Switch: Anchor to floor by bolting.
1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- B Identify components according to Division 26 Section "Identification for Electrical Systems."
- C Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

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- B Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- C Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- B Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 micro-ohms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
 - 6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

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- a. Verify grounding connections and locations and ratings of sensors.
- C Coordinate tests with tests of generator and run them concurrently.
- D Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- E Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
- B Coordinate this training with that for generator equipment.

END OF SECTION 263600

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SECTION 264113
LIGHTNING PROTECTION FOR STRUCTURES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section includes lightning protection for structures.

1.3 ACTION SUBMITTALS

- A Product Data: For each type of product indicated.
- B Shop Drawings: For air terminals and mounting accessories.
 - 1. Layout of the lightning protection system, along with details of the components to be used in the installation.
 - 2. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
 - 3. Drawings shall be sealed by a Certified Lightning Protection Designer.

1.4 INFORMATIONAL SUBMITTALS

- A Qualification Data: For qualified Designer, Installer and Manufacturer. Include data on listing or certification by UL.
- B Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.
- C Field quality-control reports.
- D Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.
- E Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:

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1. Ground rods.
2. Ground loop conductor.

1.5 QUALITY ASSURANCE

- A Installer Qualifications: Certified by UL, trained and approved for installation of units required for this Project.
- B System Certificate:
 - 1. UL Master Label Certificate.
- C Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.
- D LPI 175 - Standard of Practice for the Design - Installation - Inspection of Lightning Protection Systems.
- E Comply with Firemen's requirements.
- F Comply with Owner Design Standards.

1.6 COORDINATION

- A Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.
- C Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

PART 2 PRODUCTS

2.1 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A Comply with UL 96 and NFPA 780.
- B All components provided must be listed by UL for use with lightning protection systems.

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- C Roof-Mounted Air Terminals: NFPA 780, Class II, copper unless otherwise indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ERICO International Corporation.
 - b. Harger.
 - c. Heary Bros. Lightning Protection Co. Inc.
 - d. Thompson Lightning Protection, Inc.
 2. Air Terminals More than 24 Inches (600 mm) Long: With brace attached to the terminal at not less than half the height of the terminal.
 3. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in Division 07 roofing Sections.
 4. Air Terminals shall have "bullet" type tips. Use of sharp pointed terminals is discouraged.
- D Main and Bonding Conductors: Copper.
1. 1. Aluminum conductors shall only be used on roofs using aluminum components. Aluminum conductors shall be immediately transitioned to copper conductors by using appropriate bimetal connectors as soon as they depart from the aluminum surfaces.
 2. 2. Conductors shall be sized per NFPA 780.
- E Ground Loop Conductor: The same size and type as the main conductor except tinned.
- F Ground Rods: Copper-clad steel; 3/4 inch in diameter by 10 feet long.
- G Heavy-Duty, Stack-Mounted, Lightning Protection Components: Stainless steel.

PART 3 EXECUTION

3.1 INSTALLATION

- A Lightning protection components and systems shall be installed by a UL Master Label installer according to UL 96A and NFPA 780.
- B Submit details of all roof attachments and penetrations to the appropriate roof manufacturer and Architect for approval prior to installation.
- C Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.
- D Conceal the following conductors:
1. System conductors.
 2. Down conductors.
 3. Interior conductors.

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- 4. Conductors within normal view of exterior locations at grade within 200 feet (60 m) of building.
- E Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.
- F Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
 - 1. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.
- G Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.
- H Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.
- I Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of area or item indicated.
 - 1. Bury ground ring not less than 24 inches (600 mm) from building foundation.
 - 2. Bond ground terminals to the ground loop.
 - 3. Bond grounded building systems to the ground loop conductor within 12 feet (3.6 m) of grade level.
- J Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot (18-m) intervals.

3.2 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.3 CORROSION PROTECTION

- A Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

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3.4 FIELD QUALITY CONTROL

- A Prior to cover-up of concealed components and connections, notify Architect at least 48 hours in advance before concealing lightning protection components so that a cover-up inspection can be performed.
- B UL Inspection: Meet requirements to obtain a UL Master Label Certificate for system and turn over to Owner. The lightning protection system must pass the UL inspection. If the system does not pass inspection, the Contractor must make corrections to the system to pass inspection.

END OF SECTION 264113

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SECTION 264313
SURGE PROTECTIVE DEVICES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A Section includes field-mounted SPD for installation on existing low-voltage (120 to 480 V) power distribution equipment and factory installation for new equipment.
- B Related Sections:
 - 1. Division 26 Section "Secondary Unit Substations" for factory-installed Type 1 SPD.

1.3 DEFINITIONS

- A ATS: Acceptance Testing Specifications.
- B SPD: Surge Protective Device(s), both singular and plural.
- C SVR: Suppressed voltage rating.
- D TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

1.4 ACTION SUBMITTALS

- A Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
- B Verification that all SPD are UL tested and labeled with 20kA (In) nominal discharge rating for compliance to UL96A Lightning Protection Master Label and NFPA 780.

1.5 CLOSEOUT SUBMITTALS

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- A Operation and Maintenance Data: For SPD devices to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Replaceable Protection Modules: One for each SPD provided.

1.7 QUALITY ASSURANCE

- A Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by UL and marked for intended location and application.
- B Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.
- C Comply with NFPA 780.
- D Comply with NEMA LS 1.
- E Comply with UL 1449 and UL 1283 (Type 2 only).
- F Comply with NFPA 70.
- G Comply with Owner Design Standards.

1.8 PROJECT CONDITIONS

- A Service Conditions: Rate SPD devices for continuous operation under the following conditions unless otherwise indicated:
 - 1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
 - 2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).
 - 3. Humidity: 0 to 85 percent, non-condensing.
 - 4. Altitude: Less than 20,000 feet (6090 m) above sea level.

1.9 COORDINATION

- A Coordinate location of field-mounted SPD devices to allow adequate clearances for maintenance.

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1.10 WARRANTY

- A Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 PRODUCTS

2.1 BUILDING SERVICE ENTRANCE SWITCHBOARDS AND TRANSFER SWITCH SUPPRESSORS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Current Technology Inc.; Danaher Power Solutions.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 4. Liebert Corporation; a division of Emerson Network Power.
 - 5. Square D; a brand of Schneider Electric.
- B Surge Protection Devices Installed in Existing Service Entrance Substations:
 - 1. Type 1, Complying with UL 1449, 3rd edition, with UL card.
 - 2. SPD relying upon external or supplementary installed safety overcurrent protection do not meet the intent of this specification.
 - 3. Fabrication using bolted compression lugs for internal wiring.
 - 4. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.
 - 5. Provide a three pole circuit breaker as a dedicated disconnecting means.
 - 6. LED indicator lights for power and protection status.
 - 7. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 8. Form-C contacts rated at 5 Amp and 250-VAC, one normally open and one normally closed. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
 - 9. Six-digit transient-event counter set to totalize transient surges.
- C Surge Protection Devices Installed in new Service Entrance Substations:
 - 1. Type 1, Complying with UL 1449, 3rd edition, with UL card.
 - 2. SPD relying upon external or supplementary installed safety overcurrent protection do not meet the intent of this specification.
 - 3. Arranged for copper bus bar connections to phase buses, neutral bus, and ground bus.
 - 4. A three pole circuit breaker for dedicated disconnecting means shall be provided in the switchgear.
 - 5. LED indicator lights for power and protection status.
 - 6. Audible alarm, with silencing switch, to indicate when protection has failed.

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7. Form-C contacts rated at 5 Amp and 250-VAC, one normally open and one normally closed. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
 8. Six-digit transient-event counter set to totalize transient surges.
- D Comply with UL 1283.
- E Minimum Surge Current Capacity Rating: 250 kA per phase.
- F Nominal discharge current (In): 20 kA.
- G Short circuit current rating (SCCR): 200 kA.
- H Maximum Continuous Operating Voltage (MCOV):
1. 480/277 V: 320 V.
 2. 208/120 V: 150 V.
- I UL 1449 VPR for grounded wye circuits with 480Y/277 V, 3-phase, 4-wire circuits shall be as follows:
1. Line to Neutral: 1200 V for 480Y/277 V.
 2. Line to Ground: 1200 V for 480Y/277 V.
 3. Neutral to Ground: 1200 V for 480Y/277 V.
 4. Line to Line: 1200 V for 208/120 V.

2.2 DISTRIBUTION SWITCHBOARDS AND PANELBOARD SUPPRESSORS

- A Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Current Technology Inc.
 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 4. Liebert Corporation; a division of Emerson Network Power.
 5. Square D; a brand of Schneider Electric.
- B Products shall be installed external to existing distribution and branch panel equipment. SPD must have the same or greater AIC, Interrupting, or Fault rating of the equipment the SPD is protecting.
- C Surge Protection Devices:
1. Type 2, Comply with UL 1449, 3rd edition with UL card.
 2. Externally mounted.

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3. Short-circuit current rating complying with UL 1449, and matching or exceeding the panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
 4. SPD relying upon external or supplementary installed safety overcurrent protection do not meet the intent of this specification.
 5. Fabrication using bolted compression lugs for internal wiring.
 6. An integral safety interlocked disconnect switch with an externally mounted manual operator.
 7. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 8. LED indicator lights for power and protection status.
 9. Audible alarm, with silencing switch, to indicate when protection has failed.
 10. Form-C contacts rated at 5 Amp and 250-VAC, one normally open and one normally closed. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
 11. Six-digit transient-event counter set to totalize transient surges.
- D Products shall be factory installed in new distribution and branch panel equipment. SPD must have the same or greater AIC, Interrupting, or Fault rating of the equipment the SPD is protecting.
- E Surge Protection Devices:
1. Short-circuit current rating complying with UL 1449, and matching or exceeding the panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
 2. SPD relying upon external or supplementary installed safety overcurrent protection do not meet the intent of this specification.
 3. A three pole circuit breaker for dedicated disconnecting means shall be provided in the distribution and branch panel equipment.
 4. Fabrication using bolted compression lugs for internal wiring.
 5. Arranged for copper bus bar connections to phase buses, neutral bus, and ground bus.
 6. LED indicator lights for power and protection status.
 7. Audible alarm, with silencing switch, to indicate when protection has failed.
 8. Form-C contacts rated at 5 Amp and 250-VAC, one normally open and one normally closed. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
 9. Six-digit transient-event counter set to totalize transient surges.
- F Comply with UL 1283.
- G Minimum Surge Current Capacity Rating:
1. LV switchgear, Switchboards, MCC's, Distribution panels: minimum 160 kA.
 2. Branch Circuit Panelboards: minimum 80 kA.
- H Nominal discharge current (In): 20 kA.

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- I Short circuit current rating (SCCR): 200 kA
- J Maximum Continuous Operating Voltage (MCOV):
 - 1. 480/277 V: 320 V.
 - 2. 208/120 V: 150 V.
- K UL 1449 VPR for grounded wye circuits with 208Y/120 V, 3-phase, 4-wire circuits shall be as follows :
 - 1. Line to Neutral: 700 V for 208Y/120 V.
 - 2. Line to Ground: 700 V for 208Y/120 V.
 - 3. Neutral to Ground: 700 V for 208Y/120 V.
 - 4. Line to Line: 1200 V for 208/120 V.

2.3 ENCLOSURES

- A Indoor Enclosures: NEMA 250, Type 1.
- B Outdoor Enclosures: NEMA 250, Type 3R.

PART 3 EXECUTION

3.1 INSTALLATION

- A Type 1 SPD devices at service entrance Secondary Unit Substations shall be installed on the line side with ground lead bonded to service entrance ground.
- B Install Type 2 SPD devices for existing distribution switchgear, switchboards and panelboards externally with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
 - 1. Provide a three pole circuit breaker as a dedicated disconnecting means for each SPD unless otherwise indicated. Disconnecting means shall occupy the first three spaces in existing equipment; adjust circuit-breaker positions to achieve shortest and straightest leads.
 - 2. Use crimped connectors and splices only. Wire nuts are unacceptable.

3.2 FIELD QUALITY CONTROL

- A Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

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- B Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
 - 2. After installing SPD devices but before electrical circuitry has been energized, test for compliance with requirements.
 - 3. Complete startup checks according to manufacturer's written instructions.
- C SPD device will be considered defective if it does not pass tests and inspections.
- D Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A Do not energize or connect service entrance equipment or panelboards to their sources until SPD devices are installed and connected.
- B Do not perform insulation resistance tests of the distribution wiring equipment with the SPD installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

3.4 DEMONSTRATION

- A Train Owner's maintenance personnel to maintain SPD devices.

END OF SECTION 264313

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SECTION 265100
INTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Interior luminaires.
- B Emergency lighting units.
- C Exit signs.
- D Ballasts and drivers.

1.2 RELATED REQUIREMENTS

- A Section 260529 - NOT OEC EDITED2 - Hangers and Supports for Electrical Systems.
- B Section 260533.16 - NOT OEC EDITED2 - Boxes for Electrical Systems.
- C Section 260918 - NOT OEC EDITED - Remote Control Switching Devices: Remote controls for lighting, including network lighting controls, programmable relay panels, and remote control switching relays.
- D Section 260923 - NOT OEC EDITED2 - Lighting Control Devices.
 - 1. Includes automatic controls for lighting including occupancy sensors, outdoor motion sensors, time switches, outdoor photo controls, and daylighting controls.
- E Section 260936 - Modular Dimming Controls
- F Section 260943 - Network Lighting Controls
- G Section 26043.16 - Addressable Luminaire Lighting Controls
- H Section 26043.23 - Relay-based Lighting Controls
- I Section 262726 - Wiring Devices: Manual wall switches and wall dimmers.

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1.3 ADMINISTRATIVE REQUIREMENTS

- A Luminaires shall be provided as specified in the Luminaire Schedule or as indicated on the Drawings complete with lamps, power wiring, and control for a fully operational system. Contractor is responsible for providing proper mounting accessories. Contractor shall refer to this Specification for LED and driver requirements. Refer to the Drawings and Specifications for control requirements. Submittals shall include product information for luminaires. Where a catalog number and a narrative or pictorial description are provided, the written description shall take precedence. If equal or alternate luminaire Manufacturers are not indicated, then the luminaires shall be provided as specified. The Engineer is not responsible for the performance of substituted luminaires approved by the Architect or Owner without the consent of, or review by, the Engineer.
- B 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.

1.4 DEFINITIONS

- A CCT: Correlated color temperature.
- B CRI: Color-rendering index.
- C IP: International Protection or Ingress Protection Rating.
- D LED: Light-emitting diode.
- E LER: Luminaire efficacy rating.
- F Lumen: Measured output of lamp and luminaire, or both.
- G Luminaire: Complete lighting fixture, including lamp, reflector, and housing.

1.5 SUBMITTALS

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- A See Section 013000 - Administrative Requirements, for submittal procedures.
- B Shop Drawings:
- 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.
 - b. Include IES LM-79 test report upon request.
 - 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.
 - 3. Lamps: Include rated life, color temperature, color rendering index (CRI), and initial and mean lumen output.
- D Sustainable Design Documentation: Submit manufacturer's product data on lamp mercury content and rated lamp life, showing compliance with specified requirements.
- E Field quality control reports.
- F 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.
- G Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- H Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - NOT OEC EDITED - 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.
- I Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

1.6 QUALITY ASSURANCE

- A Comply with requirements of NFPA 70.

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- 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.

1.7 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.

1.8 FIELD CONDITIONS

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

1.9 WARRANTY

- A See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B Provide 5-year manufacturer warranty for LED luminaires, including drivers.
- C Provide 10-year pro-rata warranty for batteries for self-powered exit signs.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

- A Furnish products as indicated in luminaire schedule included on the drawings.

2.2 LUMINAIRES

- A Provide products that comply with requirements of NFPA 70.

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- 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 Color Rendering Index (CRI): Minimum CRI of 80.
- H In spaces where color quality is critical and noted on drawings, Color Fidelity shall be $R_f = 90-100$, and the Gamut Index shall be $R_g = 100-110$.
- I All interior luminaires shall have a Correlated Color Temperature (CCT) of 3500K, unless otherwise noted on the drawings.
- J 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.
- K Hazardous (Classified) Location Luminaires: Listed and labeled as complying with UL 844 for the classification of the installed location.
- L LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. All LEDs shall be batch sorted for color and brightness visual consistency, and shall be manufactured by a reputable LED Manufacturer, such as Philips Lumileds, osram Sylvania, Nichia, Cree or approved equal. All luminaires of the same type shall be supplied at the same time and shall come from the same batch. Spare luminaires shall also be provided from the same batch.
 - 4. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
 - 5. All components shall be mercury and lead-free.

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6. All luminaires shall be subjected to the following JEDEC Reliability Tests for Lead-free Semiconductors: HTOL, RTOL, LTOL, PTMCL, TMSK, Mechanical Shock, Variable Vibration Frequency, SHR, Autoclave.

- M Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

2.3 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 Lumen Output: 700 lumens minimum.
- D Battery:
1. Sealed maintenance-free nickel cadmium unless otherwise indicated.
 2. Size battery to supply all connected lamps, including emergency remote heads where indicated.
- E Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- F Provide low-voltage disconnect to prevent battery damage from deep discharge.
- G 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.
- H Accessories:
1. Provide compatible accessory mounting brackets where indicated or required to complete installation.
 2. Provide a test switch as part of the luminaire housing, or as shown on the drawings.

2.4 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.

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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.

2.5 BALLASTS AND 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.
3. Low temperature drivers shall be provided for all unheated areas.
4. Comply with FCC 47 cfr Part 18 non-consumer RFI/EMI standards.

B LED Drivers

1. Non-dimming LED Drivers shall meet the following requirements:
 - a. Minimum Efficiency: 85%
 - b. Starting Temperature: -40° C
 - c. Input Voltage: 120 to 480 volts $\pm 10\%$, single phase
 - d. Power Factor (PF): ≥ 0.90
 - e. Total Harmonic Distortion (THD): $\leq 20\%$
 - f. Sound Rating: Class A
 - g. Surge Protection: The system must survive 250 repetitive strikes of "C Low" (C Low – 6kV/1.2 x 50 μ s, 10kA/8 x 20 μ s) waveforms at 1 minute intervals with less than 10% degradation in clamping voltage. "C Low" waveforms are as defined in IEEE/ASNI C62.41.2-2002, Scenario 1 Location Category C.
 - h. UL Class I or II output power supplies.

C 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. Wall Dimmers: See Section 262726.
 - b. Daylighting Controls: See Section 260923.

2.6 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.

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PART 3 EXECUTION

3.1 TEMPORARY LIGHTING

- A If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.2 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.

3.3 INSTALLATION

- A It is the responsibility of the Electrical Contractor to include supports in Bid regardless of which Division installs the supports.
- B Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of luminaires provided under this section.
- C Perform work in accordance with NECA 1 (general workmanship).
- D Install products in accordance with manufacturer's instructions.
- E Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).
- F Provide required support and attachment in accordance with Section 260529.
- G Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- H All boxes upon which luminaires are to be installed shall be equipped with 3/8 inch luminaire studs. Luminaires which weigh over 50 lbs. shall be supported independently of the box, unless the box is listed for the weight to be supported.
- I Provide support for luminaire without causing deflection of ceiling or wall.

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- J Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- K 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 pendant-mounted luminaires to building structure.
 4. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
 5. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 6. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
 7. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
 8. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- L Recessed Luminaires:
1. Install trims tight to mounting surface with no visible light leakage.
 2. Luminaires located within accessible ceilings shall be capable of being accessed through the ceiling opening.
 3. Attach to ceiling structural members at four points equally spaced around circumference of luminaire.
- M Suspended Luminaires:
1. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 2. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet nominal length, with no more than 4 feet (1.2 m) between supports.
 3. Install canopies tight to mounting surface.
- N Wall-Mounted Luminaires:
1. Unless otherwise indicated, specified mounting heights are to center of luminaire.
 2. Attached to structural members in walls.
 3. Do not attach luminaires directly to gypsum board.
- O Install accessories furnished with each luminaire.
- P Bond products and metal accessories to branch circuit equipment grounding conductor.
- Q Emergency Lighting Units:

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R Exit Signs:

S Install lamps in each luminaire.

3.4 MOCK-UPS

- A It shall be the responsibility of the Contractor to provide a mock-up of the luminaires or lighting systems as indicated on the Luminaire Schedule or Drawings. Mock-ups shall be erected within a time period and in a location that is acceptable to the Architect
- B Mock-up installations shall closely conform to the conditions of the actual installation as to: height, distance from ceiling, material, color and etc. The Contractor shall submit a written description of each proposed mock-up with Drawings in order to obtain the Architect's approval prior to commencement of each mock-up.
- C The purpose of the mock-up will be to study the general appearance and performance of the intended lighting systems. At that time, certain minimal test variations may be requested as to luminaire location, reflector shape, color and etc. Final modifications, if any, shall be considered a part of these Specifications and shall be accomplished with no additional cost.
- D The Contractor shall coordinate the demolition of the mock-up with the Architect and Owner at the end of the viewing period.

3.5 FIELD QUALITY CONTROL

- A Test self-powered exit signs and emergency lighting units to verify proper operation upon loss of normal power supply.
- B Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A Comply with requirements for startup specified in Section 260936 - Modular Di
- B Comply with requirements for startup specified in Section 26043 - Network Lighting Controls
- C Comply with requirements for startup specified in Section 260943.16 - Addressable Luminaire Lighting Controls.
- D Comply with requirements for startup specified in Section 26043.23 - Relay-based Lighting Controls

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3.7 CLOSEOUT ACTIVITIES

- A See Section 017800 - Closeout Submittals, for closeout submittals.
- B Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.

3.8 PROTECTION

- A Protect installed luminaires from subsequent construction operations.

3.9 ADDITIONAL MATERIALS

- A The Electrical Contractor shall furnish additional materials described below that match the products installed. These materials shall be packaged with protective covering for storage, and shall be clearly labeled to indicate their use. The Contractor shall coordinate the designated storage location with the Owner on site upon project completion.
 - 1. Spare ballasts, LED drivers, LED power supplies, etc., amounting to 1% (minimum of 2) of each type and rating installed.
 - 2. Spare diffusers and lenses amounting to 1% (minimum of 2) of each type and rating installed.

END OF SECTION 265100

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SECTION 265600
EXTERIOR LIGHTING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Exterior luminaires.
- B Drivers.
- C Lamps.
- D Poles and accessories.
- E Luminaire accessories.

1.2 RELATED REQUIREMENTS

- A Section 033000 - Cast-in-Place Concrete: Materials and installation requirements for concrete bases for poles.
- B Section 260526 - Grounding and Bonding for Electrical Systems.
- C Section 260529 - NOT OEC EDITED2 - Hangers and Supports for Electrical Systems.
- D Section 260533.16 - NOT OEC EDITED2 - Boxes for Electrical Systems.
- E Section 260548 - NOT OEC EDITED2 - Vibration and Seismic Controls for Electrical Systems.
- F Section 260923 - NOT OEC EDITED2 - Lighting Control Devices.
- G Section 262726 - Wiring Devices: Receptacles for installation in poles.
- H Section 262813 - Fuses.

1.3 REFERENCE STANDARDS

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- A AASHTO LTS - Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals; 2013, with Editorial Revision (2022).
- B IEEE C2 - National Electrical Safety Code(R) (NESC(R)); 2023.
- C IES LM-63 - Approved Method: IES Standard File Format for the Electronic Transfer of Photometric Data and Related Information; 2019.
- D IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products; 2024.
- E IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources; 2021.
- F IES RP-8 - Recommended Practice: Lighting Roadway and Parking Facilities; 2022.
- G NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- H NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems; 2000 (Reaffirmed 2006).
- I NEMA 410 - Performance Testing for Lighting Controls and Switching Devices with Electronic Drivers and Discharge Ballasts; 2023.
- J NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility; 2023.
- K NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- 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.

PART 2 PRODUCTS

2.1 LUMINAIRE TYPES

- A Furnish products as indicated in luminaire schedule included on the drawings.

2.2 LUMINAIRES

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- 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, poles, foundations, 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 Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.
- H 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.
- I 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.

2.3 BALLASTS AND DRIVERS

- A Ballasts/Drivers - General Requirements:
 - 1. Electronic Ballasts/Drivers: Inrush currents not exceeding peak currents specified in NEMA 410.
- B Dimmable LED Drivers:
 - 1. Dimming Range: Continuous dimming from 100 percent to five 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.

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2.4 POLES

A All Poles:

1. Provide poles and associated support components suitable for the luminaire(s) and associated supports and accessories to be installed.
2. Structural Design Criteria:
 - a. Comply with AASHTO LTS.
 - b. Wind Load: Include effective projected area (EPA) of luminaire(s) and associated supports and accessories to be installed.
 - 1) Design Wind Speed: 120 miles per hour, with gust factor of 1.3.
 - c. Dead Load: Include weight of proposed luminaire(s) and associated supports and accessories.
3. Material: Aluminum, unless otherwise indicated.
4. Shape: Round tapered, unless otherwise indicated.
5. Finish: Match luminaire finish, unless otherwise indicated.
6. Mounting Height: Shall be as shown on drawings, unless otherwise indicated.

B Metal Poles: Provide ground lug, accessible from handhole or transformer base.

2.5 ACCESSORIES

A Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.

PART 3 EXECUTION

3.1 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.

3.2 PREPARATION

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- A Provide extension rings to bring outlet boxes flush with finished surface.
- B Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.3 INSTALLATION

- A Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of luminaires provided under this section.
- B Perform work in accordance with NECA 1 (general workmanship).
- C Install products in accordance with manufacturer's instructions.
- D Install luminaires in accordance with NECA/IESNA 501.
- E Provide required support and attachment in accordance with Section 260529.
- F Provide required seismic controls in accordance with Section 260548.
- G Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- H 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.
- I Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- J Pole-Mounted Luminaires:
 - 1. Maintain the following minimum clearances:
 - a. Comply with IEEE C2.
 - b. Comply with utility company requirements.
 - 2. Foundation-Mounted Poles:
 - a. Provide cast-in-place concrete foundations for poles as indicated, in accordance with Section 033000.
 - 1) Install anchor bolts plumb per template furnished by pole manufacturer.
 - 2) Position conduits to enter pole shaft.
 - b. Install foundations plumb.

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- c. Install poles plumb, using leveling nuts or shims as required to adjust to plumb.
 - d. Tighten anchor bolt nuts to manufacturer's recommended torque.
- 3. Grounding:
 - a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
- 4. Install separate service conductors, 12 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.

K Install accessories furnished with each luminaire.

L Bond products and metal accessories to branch circuit equipment grounding conductor.

M Install lamps in each luminaire.

3.4 FIELD QUALITY CONTROL

- A See Section 014000 - NOT OEC EDITED - 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 Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.
- E Measure illumination levels at night with calibrated meters to verify compliance with performance requirements. Record test results in written report to be included with submittals.

3.5 CLEANING

- A Clean surfaces according to NECA/IESNA 501 and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.6 CLOSEOUT ACTIVITIES

- A See Section 017800 - Closeout Submittals, for closeout submittals.
- B See Section 017900 - NOT OEC EDITED - Demonstration and Training, for additional requirements.

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- C Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.

3.7 PROTECTION

- A Protect installed luminaires from subsequent construction operations.

END OF SECTION 265600

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SECTION 266010
HEAT TRACING FOR PIPING

PART 1 GENERAL

1.1 DESCRIPTION

A SCOPE

1. This section specifies the following:
 - a. The CONTRACTOR shall furnish and install, at the locations shown on the Contract Drawings, as specified or as directed, the wire, cable, complete with shop drawings and other appurtenances, and furnish all labor, supervision, materials, appurtenances, tools and ancillary services as required for a complete and operable installation in accordance with the requirements of the Contract Documents.
 - b. In general, this WORK shall include the furnishing and installation of the following:
 - 1) Complete heat tracing system to protect piping from freezing.
 - 2) Plastic insulated, series resistance.
 - 3) Self-regulating, parallel resistance
 - c. Single Manufacturer: Like products shall be the end product of one manufacturer in order to achieve standardization of appearance, maintenance, and spare wire and cable.

B COORDINATION (NOT USED)

C RELATED SECTIONS

- a. Section 01 33 00, Submittals.
- b. Section 01 75 16, Equipment and System Start Up and Testing.
- c. Section 01 60 00, Product Requirements.
- d. Section 23 07 19, HVAC Piping Insulation.
- e. Section 26 05 05, General Provisions for Electrical Systems.
- f. Section 26 01 26, Electrical Tests.
- g. Section 26 05 53, Electrical Identification.
- h. Section 40 91 00, Process Control and Instrumentation.

1.2 REFERENCES

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

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2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEC	National Electrical Code
FM	Factory Mutual Research Corporation
NEMA	National Electrical Manufacturers Association
NESC	National Electrical Safety Code
UL 746B	Underwriters Laboratories
IEEE 515	Institute of Electrical and Electronics Engineers
ANSI	American National Standards Institute
IEC 216	International Electro-Mechanical Commission

1.3 QUALITY ASSURANCE (NOT USED)

1.4 SUBMITTALS

- A The following submittals shall be provided in accordance with Section 01 33 00 - Submittals:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the CONTRACTOR, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The ENGINEER shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the CONTRACTOR with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
 2. General: Contractor submittals shall be in accordance with the requirements of Section 01 33 00 - Submittals and 26 05 05 - General Provisions for Electrical Systems.
 3. Shop Drawings: In addition to the requirement of Section 01 33 00 - Submittals, the CONTRACTOR shall furnish the following information with the Shop Drawings.

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4. Include rated capacities, operating characteristics, and furnished specialties and accessories.
5. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.
6. Include plans, elevations, sections, and attachment details.
7. Include diagrams for power, signal, and control wiring.
8. Field quality-control reports.
9. Sample Warranty: For special warranty.
10. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.
 - a. SHIPMENT, PROTECTION AND STORAGE
 - 1) Equipment shipment, protection and storage shall conform to the requirements specified in Section 01 60 00 – Product Requirements.

1.5 WARRANTY

- A General Warranty – Refer to Article 8.5 of General Conditions.
- B Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 PRODUCTS

- 2.1 THIS PART SPECIFIES THE MATERIALS, MANUFACTURING PROCESSES, AND SALIENT FEATURES OF THE DESIRED ITEM. IT DEALS ONLY WITH WORK PERFORMED IN THE FACTORY OR BEFORE THE ITEM IS DELIVERED TO THE JOB SITE. WORK PERFORMED AT THE JOB SITE SHOULD BE SPECIFIED IN PART 3.

2.2 GENERAL

- A UL Listed or FM Approved system of heating cables, components, and controls to provide prevent pipes from freezing.

2.3 FREEZE PROTECTION CABLE SYSTEM

- A Materials

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1. The self-regulating heating cable shall consist of two (2) 16 AWG nickel- copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heating cable to be cut to length in the field. The heating cable shall be covered by a radiation-crosslinked, modified polyolefin dielectric jacket. The heating cable shall have a braid of tinned copper and an outer jacket of fluoropolymer, as required by the NEC. For installation on plastic piping, the heating cable shall be applied using cable manufacturer's recommended aluminum tape.
2. The heating cable shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heating cable output going from 40°F pipe temperature operation to 150°F pipe temperature operation.
3. The heating cable shall operate on line voltages of 120 volts.
4. The heating cable for metal-pipe freeze protection for maintaining 40 degrees F shall be sized according to the table below. The required heating cable output rating is in watts per foot at 50°F. (Heating cable selection based on 1 inch fiberglass insulation on metal piping. See Section 23 07 19 - HVAC Piping Insulation).
5. Minimum Ambient Temperature

Pipe Size	0°	-20°F
3 or less	5 watts	5 watts
4	5 watts	8 watts
6	8 watts	8 watts
8	8 watts	2 strips-5 watts
10	2 strips-5 watts	2 strips-8 watts

6. Power connection, end seal, splice and tee kit components shall be applied in the field.
7. Heating cable circuit shall be protected by a ground-fault device for equipment protection. This requirement is in accordance with the NEC- 2014.

B Components

1. All heating-cable components shall be UL Listed or FM Approved for use as part of the system to provide pipe freeze protection. Component enclosures shall be rated NEMA 4X to prevent water ingress and corrosion.

C System Control

1. Thermostatic Control—Line Sensing: The system shall be controlled by a line sensing thermostat: fixed at 40°F.

D Control Panel

1. All control components shall be located in a NEMA-12 enclosure.
2. Control panel shall contain a main breaker sized for the load for single point connection.
3. Distribution circuit breakers or fuses shall be provided to each load.
4. LCD display shall be provided to indicate temperature and power for each circuit.

E Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Thermon, Type BSX.

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2. Delta-Therm Corporation.
3. Raychem; a brand of Tyco Thermal Controls LLC.

2.4 ACCESSORIES

- A Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

PART 3 EXECUTION

3.1 EXAMINATION

- A Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
- B Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.
- B Install electric heating cables after piping has been tested and before insulation is installed.
- C Install electric heating cables according to IEEE 515.1.
- D Install warning tape on piping insulation where piping is equipped with electric heating cables.
- E Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

- A Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

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- B Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B Perform the following tests and inspections:
 - 1. Procedure: Measure the heater circuit continuity and the insulation resistance between the braid and the bus wires with a 2500 Vdc megohmmeter (megger).
 - 2. While the cable is still on the reels, prior to installation.
 - 3. After installation of the heating cable and completion of circuit fabrication kits (including all splice kits) but prior to installation of thermal insulation.
 - 4. After installation of thermal insulation.
 - 5. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
 - 6. Test cables for electrical continuity and insulation integrity before energizing.
 - 7. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.
- C Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.
- D Cables will be considered defective if they do not pass tests and inspections.
- E Prepare test and inspection reports.

END OF SECTION 266010

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SECTION 270000
COMMUNICATIONS WORK

PART 1 GENERAL

1.1 DESCRIPTION

- A All Contractor work, methods, and materials for Telecommunications systems must comply with Wayne State University Standards for Communications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).
- B Refer to Division 26 specifications for related specification Sections.
- C The work required under this Division consists of furnishing all equipment, accessories, hardware, materials, tools, transportation, and performing all services and labor required to successfully install and test the communications work for the Project, as specified herein and shown on the plans, in place and complete.
- D References in this Division to codes, industry-wide standards and specifications, or nationally recognized testing agencies shall denote the latest edition of such publication in force on the date of the Contract, unless otherwise specified.
- E Execute all work in conformity with standard practices to accommodate work to environment and surroundings. Perform all work in accordance with drawings, manufacturer's instructions, shop drawings, this specification, and other Contractors, Trades, and Vendors.
- F Coordinate locations and arrangements of equipment with requirements of all other Contractors, Trades, Vendors, Architect, and Owner. In cases of technical configuration or implementation difficulties, or if simplified installation is made possible by slight variance, bring such conditions to attention of Architect, in writing, via fax, electronic mail, or letter. Changes in arrangements may be made only if authorized by Architect.
- G Drawings are diagrammatic and indicate the general arrangement of systems and work included in these documents. Final placement and arrangement are the responsibility of the Installing Contractor.

1.2 QUALITY ASSURANCE

- A Furnish only new, first-class quality materials and equipment to be delivered, erected, connected, and finished in every detail, selected, and arranged to fit properly into spaces. Where no specific kind or quality of material is specified, furnish first-class quality standard article, approved by Architect.

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- B Furnish services of one or more experienced project managers to oversee the installation of work, and all skilled workmen, and laborers required to unload, transfer, erect, connect, adjust, start, operate, and test each system.
- C Installation Qualifications: Division 27 Contractor must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings by a Registered Communications Distribution Designer (RCDD).
 - 2. Installation Supervision: Installation shall be under the direct supervision of Project Foreman. Project Foreman shall be present, at all times, when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- D Comply with latest edition or revision of each standard or code mentioned in these specifications for use in the intended environment and as follows:
 - 1. American Institute of Architects (AIA)
 - 2. American National Standard Institute (ANSI)
 - 3. Building Industry Consulting Service International (BICSI).
 - 4. Federal Communications Commission (FCC)
 - 5. Institute of Electrical and Electronics Engineers, Inc. (IEEE)
 - 6. International Organization for Standardization (ISO)
 - 7. National Electrical Manufacturers Association (NEMA)
 - 8. National Fire Protection Association (NFPA)
 - a. National Electrical Code (NEC) - NFPA 70. Current adopted edition enforced by the Authority Having Jurisdiction (AHJ).
 - 9. Telecommunications Industries Association (TIA)
 - 10. Underwriters' Laboratories (UL)
 - 11. Occupational Safety and Health Administration (OSHA)
 - 12. State and Local Municipality Codes and Ordinances
- E Where conflicts occur between codes and standards or between codes and standards and Specifications and Plans, the one establishing the more stringent requirements shall be followed.
- F All support services shall be conducted to the satisfaction of the Owner.

1.3 SUBMITTALS

- A As indicated in the Wayne State University Standards for Communications Infrastructure.
- B Submittal Package

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1. Prior to ordering material and starting installation, submit indexed and bound set of shop documentation and/or product data sheets for items identified in individual sections of Division 27 in PDF format. Index shall list product being submitted and bid section number for reference (e.g., 271000.2.2.A – Unshielded Twisted Pair Conductors). Product data sheets shall be clearly marked indicating product compliance with the Specifications.
2. Product data will be highlighted (via highlighted text; colored encapsulation, arrows or pointers, or other distinctive designation) to identify the following:
 - a. Pertinent models or part numbers.
 - b. Performance characteristics.
 - c. Capacities.
 - d. Dimensions and clearances required.
 - e. Wiring diagrams and controls.
 - f. Other pertinent information.
3. Provide all submittals for the following for each section and in accordance with specific requirements of individual Sections in Division 27:
 - a. Product data sheets for all products listed on bid supplements.
 - b. Statement of warranty.
 - c. Documentation of procedure to initiate warranty service call.
 - d. Layout of wall mounted equipment, including dimensions, available space, and physical arrangement.
 - e. Layout of cabinet/rack mounted equipment, including dimensions, available space, and physical arrangement.
 - f. Certification of factory authorization of installation and service for components bid.
 - g. Detailed work plan, including schedule.
 - h. Proposed construction details for any custom fabricated items, including interface panels, removable control panels, and wall panels. Detail shall show dimensions, materials, finishes, and color selection.
4. Submittal packages not clearly identified with the following will be rejected and resubmission will be required:
 - a. Project name, number, and location.
 - b. Company name of submitter.
 - c. Submitting reviewer's initials.
 - d. Date of review by submitter.
5. All submittal packages shall be clearly marked with "Project Name - Division # Submittals".
6. A Letter of Transmittal shall accompany all submittals.
 - a. Letter of Transmittal shall include the following information:
 - 1) Date of submittal.
 - 2) Name of Company making submittal.
 - 3) Name of Contractor/Individual sending submittal.
 - 4) Job number.
 - 5) Itemized list of enclosures (e.g., "one copy of Section # Submittals").
 - 6) Recipient name and department.
 - 7) Action to be taken (e.g., "please review submittals for approval").
 - b. Letter of Transmittal shall be addressed to the intended recipient.

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C Architect's Review

1. Review of shop drawings by the Architect does not relieve the Contractor of responsibility for errors, correctness of details, or conformance with the Contract.

1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A As indicated in the Wayne State University Standards for Communications Infrastructure.
- B Protect materials before, during, and after installation.
- C In the event of damage, immediately make all repairs and replacement necessary to restore the material to its original state at no additional cost.
- D Deliver all material to the project site in original unopened containers, where applicable or unless noted otherwise, with all labels intact and legible at time of use. Store in strict accordance with manufacturer's recommendations.
- E Owner will not make provisions for temporary storage of products prior to deployment in specified locations. In any case, all costs incurred in storage, setup, handling, and transportation shall be included in bid.
- F Owner assumes no responsibility for stored equipment. The ownership and title to equipment shall not be vested in the Owner before the equipment has been delivered, tested, and accepted. Therefore, all equipment shall be fully insured by the successful bidder until final acceptance by the Owner.

PART 2 PRODUCTS

2.1 GENERAL

- A Include all tools, mounting brackets, rack mounting kits/shelves, screws, and other hardware necessary to properly and adequately install, de-install, or reconfigure equipment.
- B Include all necessary cables connectors and/or software necessary to install, configure, manage, or operate equipment for the purposes intended.
- C Include all required hardware to adequately and safely support all mounted equipment.

2.2 MATERIALS AND MANUFACTURERS

- A As indicated in the Wayne State University Standards for Communications Infrastructure.

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PART 3 EXECUTION

3.1 INSTALLATION

- A Contractor shall provide personnel that are fully certified by the manufacturer(s) for all products and systems installed or modified and all equipment used. All applicable certifications shall be kept current during entire project.
- B Perform all work in close cooperation with all other trades.
- C Unpack, set in place, completely assemble all items, and make final connections. Remove all packing cartons and materials from the building and site.
- D Properly level, anchor, and/or mount items to floor or wall or other surfaces as required.
- E Install all equipment and systems according to manufacturers' recommendations.
- F Do not install any product where it might be exposed to an environment that is different to that in which it was intended to be normally used. Consult with Architect in such instances.
- G Comply with working clearances and dedicated spaces per Federal, State, and Local regulation.
- H Relocate any improperly located equipment or device, and replace any incorrect connection caused by lack of preparation or coordination. Repair to satisfaction of Owner/Architect any hole, etc., caused by these relocations/replacements at no additional cost to Owner.
- I Cables and Wires
 1. Dress all cables, including service loops, in a neat workmanship-like manner in strict accordance with industry-wide standards.
 2. Cables with excessive strain and tension applied to them shall be replaced by Contractor at no additional cost at Owner's or Architect's discretion.
 3. Run all cables and wires continuously from termination point to termination. No mid-run cable splices shall be allowed.
 4. All cables shall be installed per Manufacturer's recommendations and shall follow recommended bend radius guidelines.
 5. Cables and wires within racks and cabinets shall be neatly installed, completely terminated, and routed in such a way that allows direct, unimpeded access to the equipment within the enclosure. All cables and wires shall be bundled and secured with tie wraps, Velcro, and/or other approved fasteners appropriate for Category rated or security system specific cables.
 6. Make connections in accordance with the manufacturer's recommendations. Wire nuts shall not be an acceptable means of connecting cables and wires.

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J Fire Stopping

1. Provide firestop materials at all penetrations with a certified firestopping system as required.
 - a. Firestop, firestopping assemblies, and firestopping methods shall be appropriate for the barrier type and barrier rating of the penetration made.
 - b. Substitution and mixing of materials, resulting in an uncertified system is not acceptable.
 - c. Contractor shall install firestop and ensure firestop installation creates a certified firestop system meeting or exceeding the rating of the penetrated barrier.
2. Contractor shall label all firestop penetrations.
 - a. Label shall, in some fashion, show the following alerts:
 - 1) "WARNING"
 - 2) "FIRESTOP SYSTEM"
 - 3) "DO NOT REMOVE"
 - b. Label shall display the following information:
 - 1) UL System Number
 - 2) Firestop System Manufacturer
 - 3) Manufacturer Assembly Number
 - 4) Installing Company Name
 - 5) Installer Name
 - 6) Date of Installation
3. Contractor shall submit, to Architect, all certified firestop system and assembly Data Sheets.

3.2 IDENTIFICATION

- A As indicated in the Wayne State University Standards for Communications Infrastructure.
- B Systems components shall be identified on each item with high quality, smear resistant, mechanically imprinted markers, and established for logical identification in compliance with TIA-606 specifications and/or Owner's direction. Labels shall meet or exceed the legibility, defacement, and adhesion requirements specified in UL 969, and meet or exceed the general exposure requirements in UL 969 for indoor use.
1. Labeling identifiers shall be "Class of Administration" compliant.
 2. Labels shall be black type on white background, or as coordinated with WSU C&IT.

3.3 FIELD QUALITY CONTROL

- A Testing
1. As indicated in the Wayne State University Standards for Telecommunications Infrastructure.
 2. Test all components per manufacturer's recommendations. Make system corrections as required.

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3. Upon completion of the project, submit written report with certified test reports to Architect and Owner stating results of tests conducted and actions taken as result of tests.
4. Personnel conducting testing shall be fully trained and certified on all test equipment used.

3.4 ADJUSTMENTS AND CLEANING

A Cutting and Patching

1. Do all cutting and patching necessary for installation of work with approval of the Architect.
2. Do not impair strength or function of work being cut or patched, e.g., do not weaken structural members and maintain watertight integrity where necessary.
3. Use rotary type drilling tools and concrete cutting saws to cut concrete and masonry walls.
4. Use rotary type drilling tools to cut cabinets where knockouts are not available, and cable access is required. Do not use torches for cutting metal.

B Housekeeping and Cleanup

1. Remove from site all debris and rubbish accumulating as a result of installation. Properly dispose of all debris and rubbish. Leave all rooms and facilities in which you work "broom clean."
2. Clean all equipment at time of substantial completion. Clean interiors and exteriors of all cabinets, furniture, and equipment enclosures. Clean out all debris and rubbish related to the installation of the Technology System(s) for all Equipment Room, Telecommunications Room, and Demarcation locations. All equipment shall appear in first class new condition.

3.5 RECORD DOCUMENTS

A As indicated in the Wayne State University Standards for Communications Infrastructure.

B Component Listing

1. Provide Record Documents in .pdf file format. Submit documents electronically via email or other approved electronic media. Tabulate documents, for each component, piece of equipment or device including:
 - a. Component manufacturer.
 - b. Component part number.
 - c. Component description.
 - d. Owner identification label.
 - e. Installed location (Architectural Room Number).
 - f. Component serial number.
 - g. Other specifications, etc., per building, to facilitate maintenance or replacement.

C Manufacturer's Warranties and Operating Instructions

1. Provide warranty and operating instruction documents, for each equipment item furnished, in .pdf file format. Bookmark and index documents. Submit documents electronically via email or other approved electronic media.

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D Record ("As-Built") Drawings

1. As indicated in the Wayne State University Standards for Telecommunications Infrastructure.
2. The Contractor shall maintain a complete, accurate, and up-to-date set of record "As-Built" documentation and drawings at the jobsite during the course of installation. Copies of completed record documents and drawings shall be turned over to the Architect at the completion of work.

3.6 WARRANTY

A As indicated in the Wayne State University Standards for Communications Infrastructure.

B Warranty shall include the following services:

1. Telephone based engineering and/or support to assist Owner personnel with configuration and design matters.
2. Provide all parts, labor, and travel required to restore any failing material to its intended operating condition at the Owner's chosen location.
3. Work performed during the warranty period shall be done without additional charge or fee.

C All services shall be available between 8:00 a.m. and 5:00 p.m., Monday through Friday.

1. Holidays observed by the Owner are excluded.

END OF SECTION 270000

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SECTION 270524
FIRESTOPPING FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION

- A Provide fire stopping for the Division 27 portions of the project. Should conflicts arise between this portion of the requirements and those required by the Architectural Specifications, the Contractor shall utilize the more stringent requirements.

1.2 SECTION INCLUDES

- A Firestopping of Through Penetrations in Fire Rated Assemblies.
- B Smoke Seals.
- C Construction enclosing compartmentalized areas.

1.3 RELATED SECTIONS

- A Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

1.4 REFERENCE STANDARDS

- A ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2024.
- B ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials; 2022.
- C ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems; 2023a.
- D UL 263 - Standard for Fire Tests of Building Construction and Materials; Current Edition, Including All Revisions.
- E UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

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- F UL 1479 - Standard for Fire Tests of Penetration Firestops; Current Edition, Including All Revisions.

1.5 PERFORMANCE REQUIREMENTS

- A Fire rated pathway devices shall be the preferred product and shall be installed in all locations where frequent cable moves, adds and changes will occur.
- B Where non- mechanical products are utilized, provide products that upon curing do no re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during or after construction.
- C Where it is not practical to use a mechanical device, openings within floors and walls designed to accommodate telecommunications and data cabling shall be provided with re-enterable products that do not cure or dry.
- D Openings for cable trays shall be sealed using re-enterable firestopping pillows.

1.6 SUBMITTALS

- A All submittals shall conform completely with the requirements of the Contract Documents.
- B Product Data
1. For each type, provide manufacturer's standard catalog data for specified products demonstrating compliance with referenced standards and listing numbers of systems in which each product is to be used.
- C Shop Drawings
1. Submit schedule of opening locations and sizes, penetrating items, and required listed design numbers to seal openings to maintain fire resistance ratings. Show typical installation details including:
 - a. Minimum and maximum allowable annular spacing
 - b. Base material composition
 - c. Firestop materials selected
 - d. Applied thickness required to achieve the hourly rating
- D Certificates
1. Submit product certificates signed by firestop system manufacturer certifying material compliance with applicable code and specified performance characteristics.
- E Installation Instructions
1. Submit manufacturer's printed installation instructions.

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1.7 QUALITY ASSURANCE

- A Products/Systems: Provide firestopping systems that comply with the following requirements:
 - 1. Firestopping tests are performed by a qualified, testing and inspection agency. A qualified testing and inspection agency is UL, or another agency performing testing and follow-up inspection services for firestop system acceptable to authorities having jurisdiction.
 - 2. Firestopping products bear the classification marking of qualified testing and inspection agency.
- B Installer Qualifications: Experience in performing work of this section who is qualified by the firestopping manufacturer as having been provided the necessary training to install firestop products in accordance with specified requirements.

1.8 DELIVERY, STORAGE, AND HANDLING

- A Delivery:
 - 1. Manufacturer's original, unopened, undamaged containers, identification labels intact identifying product and manufacturer, date of manufacture; lot number; shelf life, if applicable; qualified testing and inspection agency's classification marking; and mixing instruction for multicomponent products.
 - 2. Handle and store products according to manufacturer's recommendations published in technical materials. Leave products wrapped or otherwise protected and under clean and dry storage conditions until required for installation.
- B Storage and Protection:
 - 1. Store materials protected from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

1.9 PROJECT CONDITIONS

- A Do not install firestopping products when ambient or substrate temperatures are outside limitations recommended by manufacturer.
- B Do not install firestopping products when substrates are wet due to rain, frost, condensation, or other causes.
- C Maintain minimum temperature before, during, and for a minimum 3 days after installation of materials.
- D Do not use materials that contain flammable solvents.
- E Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

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- F Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.
- G Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

1.10 WARRANTY

- A Contractor shall provide written certification that all firestopping was installed in accordance with the manufacturer's written instructions for UL tested assemblies and that all firestop systems installed meet the firestopping requirements as herein specified.

1.11 COORDINATION

- A Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.
- B Coordinate sizing of sleeves, openings, core-drilled holes or cut openings to accommodate through-penetration firestop systems.
- C Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

1.12 PROTECTION

- A Where firestopping is installed at locations which shall remain exposed in the completed work, provide protection as necessary to prevent damage to adjacent surfaces and finishes, and protect as necessary against damage from other construction activities.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Single Source: Obtain firestop systems for each type of penetration and construction condition indicated only from a single manufacturer.

2.2 MATERIALS

- A General: Use only firestopping products that have been tested for specific fire resistance rated construction conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire rating involved for each separate instance.

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- B Fire Rated Cable Pathways: Factory manufactured devices comprised of steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill, the following products are acceptable:
 - 1. Specified Technologies Inc. (STI) EZ-PATH™ Fire Rated Pathway
 - 2. As approved by WSU C&IT.

- C Latex Sealants: Single component latex formulations that upon cure do not re-emulsify during exposure to moisture, the following products are acceptable:
 - 1. Specified Technologies Inc. (STI) SpecSeal® Series SSS Sealant
 - 2. Hilti Elastic Firestop Sealant
 - 3. 3M Fire Barrier Silicone Sealant

- D Firestop Putty: Intumescent, non-hardening, water resistant putties containing no solvents, inorganic fibers or silicone compounds, the following products are acceptable:
 - 1. Specified Technologies Inc. (STI) SpecSeal® Series SSP Putty
 - 2. Hilti Firestop Putty
 - 3. 3M Fire Barrier Moldable Putty

- E Firestop Pillows: Re-enterable, non-curing, mineral fiber core encapsulated with an intumescent coating contained in a flame-retardant poly bag, the following products are acceptable:
 - 1. Specified Technologies Inc. (STI) SpecSeal® Series SSB Pillows
 - 2. Hilti Firestop Cushions
 - 3. 3M Fire Barrier Pillows

PART 3 EXECUTION

3.1 EXAMINATION

- A Before beginning installation, verify that substrate conditions previously installed under other sections are acceptable for installation of firestopping in accordance with manufacturer's installation instructions and technical information.

- B Surfaces shall be free of dirt, grease, oil, scale, laitance, rust, release agents, water repellants, and any other substances that may inhibit optimum adhesion.

- C Provide masking and temporary covering to protect adjacent surfaces.

- D Do not proceed until unsatisfactory conditions have been corrected.

- E Verify that environmental conditions are safe and suitable for the installation of the firestop products.

3.2 INSTALLATION

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- A General: Install through-penetration firestop systems in accordance with Performance Criteria and in accordance with the conditions of testing and classification as specified in the published design.
- B Manufacturer's Instructions: Comply with manufacturer's instructions for installation of firestopping products.
- C All firestopping shall be installed in accordance to the UL rated system designed for the application.
- D Sleeves and core-drilled holes shall be sized at least 1-1/2" larger in diameter than penetrating items.
- E Installation of firestops shall be performed by applicators/installers qualified and trained by the Manufacturer.
- F Coordinate with plumbing, mechanical, electrical and other trades to assure that all conduits, raceways, cables, cable trays, and other equipment which penetrate fire rated construction have been permanently installed prior to installation of firestops. Schedule and sequence the work to assure that partitions and other construction which would conceal penetrations are not erected prior to the installation of firestop.
- G Gun grade sealants and putties shall be tooled into place to insure proper adhesion to penetrations and surrounding surfaces.

3.3 FIELD QUALITY CONTROL

- A Keep areas of work accessible until inspection by authorities having jurisdiction.
- B Where deficiencies are found, repair firestopping products so they comply with requirements.
- C Install work in full accordance with the rules, regulations, and safety requirements of Federal, State, County and City authorities having jurisdiction over premises. Do not construe this as relieving Contractor from compliance with any requirements of the Specifications which are in excess of Code requirements and not in conflict therewith.
- D Correct unacceptable firestopping and provide additional inspection to verify compliance with this Specification at no additional cost.
- E Finish surfaces of firestopping that is to remain exposed in the completed work to a uniform and level condition.

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3.4 ADJUSTING AND CLEANING

- A Remove equipment, materials, and debris, leaving area in undamaged, clean condition.
- B Clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling as work progresses.

END OF SECTION 270524 270524

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SECTION 270526
GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Selection and installation of communications bonding conductors.

1.2 DEFINITIONS

- A BBC: Backbone bonding conductor, for connecting multiple TBBs serving the same floor.
- B PBB: Primary bonding busbar, located in main distribution frame room, ideally near electrical service entrance.
- C RBB: Rack bonding busbar, located in equipment cabinets and racks.
- D SBB: Secondary bonding busbar, located in intermediate distribution frame rooms.
- E TBB: Telecommunications bonding backbone, for connecting SBBs to PBB.
- F TBC: Telecommunications bonding conductor, for connecting PBB to intersystem bonding termination device or busbar at electrical service entrance.
- G TEBC: Telecommunications equipment bonding conductor, for connecting RBBs to SBBs or PBB.
- H UBC: Unit bonding conductor, for connecting individual communications equipment to RBBs or SBBs.

1.3 REFERENCE STANDARDS

- A BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition; 2019.
- B BICSI N3 - Planning and Installation Methods for the Bonding and Grounding of Telecommunication and ICT Systems and Infrastructure; 2020.

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- C NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D TIA-568.1 - Commercial Building Telecommunications Infrastructure Standard; 2020e.
- E TIA-568.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards; 2018d, with Addenda (2020).
- F TIA-607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises; 2019d, with Addendum (2021).

1.4 ACTION SUBMITTALS

- A Shop Drawings:
 - 1. Include plans, elevations, sections, details, and attachments to other work.
- B Field Quality-Control Submittals:
 - 1. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

- A Manufacturers' Published Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:
 - 1. Installing wire connector on conductor.
 - 2. Recommended torque values.

1.6 CLOSEOUT SUBMITTALS

- A Record Documentation: Project record documents in accordance with Section 270100 Communications Common Work Results. "Project Record Documents" must include locations of PBB and SBBs, and routing of TBC, TBBs, and BBCs.

PART 2 PRODUCTS

- 2.1 AS INDICATED IN THE COREWELL HEALTH'S DIVISION 27 STANDARDS FOR COMMUNICATION SYSTEMS.

PART 3 EXECUTION

- 3.1 EXAMINATION

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- A Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.
- B Inspect test results of grounding system measured at point of TBC connection.
- C Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D Proceed with connection of TBC only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF COMMUNICATIONS BUSBARS

- A Unless otherwise indicated in this Section or on Drawings, provide products specified in related Division 26 Grounding and Bonding specification sections.
- B PBB:
 - 1. Dimensions: 1/4" thick by 4 inches (101.6 mm) high.
 - 2. Stand-Off Distance: minimum 2 inches (50.8 mm)
- C SBB:
 - 1. Dimensions: 1/4 inch (6.35 mm) thick by 4 inches (101.6 mm) high.
 - 2. Stand-Off Distance: minimum 2 inches (50.8 mm).

3.3 SELECTION OF COMMUNICATIONS BONDING CONDUCTORS

- A Unless otherwise indicated in this Section or on Drawings, provide products specified in related Division 26 Grounding and Bonding specification sections.
- B Communications Busbar Connections:
 - 1. TBC: Not smaller than 1/0 AWG and no smaller than largest TBB.
 - 2. TBB: Not smaller than 2 kcmil per linear ft of conductor length, but not larger than 750 kcmil, unless otherwise indicated on Drawings.
 - 3. BBC: Not smaller than largest TBB to which it is connected unless otherwise indicated on Drawings.
 - 4. TEBC: Not smaller than 2 AWG unless otherwise indicated on Drawings. Provide bolted connectors.
 - 5. UBC: Not smaller than 6 AWG unless otherwise indicated on Drawings. Provide bolted connectors.
 - 6. Bonding Conductors to Structural Steel: Not smaller than 6 AWG unless otherwise indicated on Drawings. Provide bolted clamp connectors.

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- C Cable Tray Connections:
 - 1. Cable Tray Equipment Grounding Conductor: 6 AWG.
 - 2. Cable Tray Bonding Jumper: If not supplied by cable manufacturer, provide bonding jumper not smaller than 6 AWG and not longer than 12 inches. If jumper is wire, it must be terminated with lug having one hole and standard barrel for one crimp. If jumper is flexible braid, it must be terminated with one-hole ferrule. Attach with bonding screw or connector provided by cable tray manufacturer.

- D Underground Connections: Not smaller than 2 AWG. Provide welded connectors, except bolted connectors may be used in handholes or manholes and as otherwise indicated on Drawings.

3.4 SELECTION OF SIGNAL REFERENCE GRIDS

- A Unless otherwise indicated in this Section or on Drawings, provide products specified in related Division 26 Grounding and Bonding specification sections.

3.5 INSTALLATION OF BONDING FOR COMMUNICATIONS

- A Comply with manufacturer's published instructions.

- B Reference Standards:
 - 1. Bonding of Communications: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with BICSI N3.
 - 2. Consult Architect for resolution of conflicting requirements.

- C Special Techniques:
 - 1. Busbars:
 - a. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 12 inches (304.8 mm) above finished floor unless otherwise indicated.
 - b. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
 - 2. Conductors:
 - a. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
 - b. Assemble wire connector to conductor, complying with manufacturer's published instructions and as follows:
 - 1) Use crimping tool and die specific to connector.
 - 2) Pretwist conductor.
 - 3) Apply antioxidant compound to bolted and compression connections.

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- c. Install in straightest and shortest route between origination and termination point, and no longer than required. Bend radius must not be smaller than 10 times diameter of conductor. No single bend may exceed 90 degrees.
 - d. Install without splices.
 - e. Support conductors at not more than 36-inch intervals.
 - f. Outside telecommunications rooms, install conductors in metric designator 21 (trade size 3/4) PVC-80 conduit until conduit enters telecommunications room. Install bonding conductors in EMT-A or EMT-SS when routed through plenum. Do not install bonding conductors in EMT-S unless otherwise indicated on Drawings.
 - 1) If bonding conductor must be installed in EMT-S or other ferrous metallic raceway, bond conductor to raceway using grounding bushing that complies with Section 270528 "Pathways for Communications Systems," and bond both ends of raceway to SBB.
- 3. Provide TBC and terminate ends to PBB and intersystem bonding busbar at electrical service entrance in accordance with Section 250.94, "Bonding for Communication Systems," of NFPA 70.
 - 4. Busbar Interconnections: Bond SBBs to PBB with TBBs. If more than one TBB is installed, bond TBBs together BBCs where required by TIA-607.
 - 5. Structural Steel: Where structural steel of steel frame building is readily accessible within room or space, bond each SBB and PBB to vertical steel of building frame.
 - 6. Communications Enclosures: Bond metallic enclosures of telecommunications equipment with UBCs to nearest SBB or PBB.
 - 7. Equipment Racks: Bond metallic components of enclosures to RBB using UBCs. Provide top-mounted RBB if not provided by enclosure or rack manufacturer. Bond RBB to SBB with TEBC. Power connection must comply with NFPA 70; equipment grounding conductor in power cord of cord- and plug-connected equipment must be considered supplemental to bonding requirements in this Section.
 - 8. Shielded Cable: Bond shield of shielded cable to SBB in communications rooms and spaces. Comply with TIA-568.1 and TIA-568.2 when grounding shielded balanced twisted-pair cables.
 - 9. Primary Protector: Bond to PBB with insulated bonding conductor.
 - 10. Electrical Power Panelboards: Where electrical panelboards for communications equipment are located in the same room or space, bond each ground bar of panelboard to SBB.
 - 11. Cable Trays: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
 - 12. Ladder Racks: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
 - 13. Access Floors: Bond metal parts of access floors to SBB.

3.6 IDENTIFICATION

- A Comply with Corewell Health's Division 27 Standards for Communications Systems.

3.7 FIELD QUALITY CONTROL

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A Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench according to manufacturer's published instructions.
2. Test bonding connections of system using AC earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing PBB or SBB, using process recommended by BICSI N1. Conduct tests with facility in operation.
 - a. Measure resistance between PBB and electrical service intersystem termination point. Maximum acceptable value is 100 m Ω .
 - 1) If measured resistance from electrical service equipment to ground exceeds 5 Ω , notify Architect and include recommendations to reduce resistance to ground.
 - b. Measure resistance between SBBs and PBB. Maximum acceptable value is 100 m Ω .
3. Test for ground loop currents using digital clamp-on ammeter, with full scale not more than 10 A, displaying current in increments of 0.01 A at accuracy of plus or minus 2.0 percent.
 - a. With grounding infrastructure completed and communications system electronics operating, measure current in bonding conductors connected to PBB and to SBBs. Maximum acceptable AC current level is 1 A.

B Nonconforming Work:

1. Communications bonding will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C Collect, assemble, and submit test and inspection reports.

3.8 PROTECTION

- A After installation, protect busbars and conductors from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 270526 270526

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SECTION 270529
HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Support and attachment requirements and components for equipment, conduit, cable, boxes, and other communications work.

1.2 RELATED REQUIREMENTS

- A Section 270533.13 - Conduit for Communications Systems: Additional support and attachment requirements for conduits.
- B Section 271000 - Structured Cabling.

1.3 REFERENCE STANDARDS

- A ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- B ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.
- C ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2023.
- D BICSI ITSIMM - Information Technology Systems Installation Methods Manual (ITSIMM), 8th Edition; 2022.
- E BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition; 2019.
- F MFMA-4 - Metal Framing Standards Publication; 2004.
- G NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.

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- H NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I TIA-569 - Telecommunications Pathways and Spaces; 2019e, with Addendum (2022).
- J UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.
 - 2. Coordinate work to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
 - 4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
 - 5. Notify Architect of 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 cured; see Section 033000.

1.5 SUBMITTALS

- A See Section 013000 - Administrative Requirements for submittal procedures.
- B Product Data: Provide manufacturer's standard catalog pages and data sheets for cable supports, channel/strut framing systems, nonpenetrating rooftop supports, and post-installed concrete/masonry anchors.

PART 2 PRODUCTS

2.1 SUPPORT AND ATTACHMENT COMPONENTS

- A General Requirements:
 - 1. Comply with the following. Where requirements differ, comply with most stringent.
 - a. TIA-569.
 - b. NFPA 70.

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- c. Applicable building code.
 - d. Requirements of authorities having jurisdiction.
 - 2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of communications work.
 - 3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
 - 4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported with a minimum safety factor of 2.5. Include consideration for vibration, equipment operation, and shock loads where applicable.
 - 5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
 - 6. Steel Components: Use corrosion-resistant materials suitable for 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 Conduit Supports: Straps and clamps suitable for conduit to be supported.
- 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
 - 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C Noncontinuous Cable Supports: J-hooks, specifically designed for routing of Category rated cable.
- 1. Manufacturers:
 - a. B-Line
 - b. nVent Caddy
 - c. Panduit
 - 2. Applications:
 - a. Do not exceed 5 feet (1.5 m) between cable supports.
 - b. Maximum Number of Cables per Cable Support:
 - 1) J-Hooks: 50, regardless of capacity.
 - 3. Cable Supports Installed in Spaces Used for Environmental Air: Plenum rated; listed and labeled as complying with UL 2043, suitable for use in air-handling spaces.
- D Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.
- E Metal Channel/Strut Framing Systems:
- 1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
 - 2. Comply with MFMA-4.

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- F Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.
- G Anchors and Fasteners:
 - 1. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.

PART 3 EXECUTION

3.1 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.

3.2 INSTALLATION

- A Install products in accordance with manufacturer's instructions.
- B Install hangers and supports in accordance with NECA 1, BICSI ITSIMM, and BICSI N1.
- 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.

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4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H Secure fasteners in accordance with manufacturer's recommended torque settings.
- I Remove temporary supports.

END OF SECTION 270529 270529

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SECTION 270533.13
CONDUIT FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Galvanized steel rigid metal conduit (RMC).
- B Stainless steel rigid metal conduit (RMC).
- C Galvanized steel intermediate metal conduit (IMC).
- D Stainless steel intermediate metal conduit (IMC).
- E Flexible metal conduit (FMC).
- F Liquidtight flexible metal conduit (LFMC).
- G Galvanized steel electrical metallic tubing (EMT).
- H Stainless steel electrical metallic tubing (EMT).
- I Aluminum electrical metallic tubing (EMT).
- J Rigid polyvinyl chloride (PVC) conduit.
- K Liquidtight flexible nonmetallic conduit (LFNC).
- L High-density polyethylene (HDPE) conduit.
- M Polyvinyl chloride (PVC) plastic utilities duct.
- N Inside-plant flexible nonmetallic communications raceway/innerduct.

1.2 RELATED REQUIREMENTS

1.3 REFERENCE STANDARDS

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- 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 ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit; 2018.
- D ASTM F512 - Standard Specification for Smooth-Wall Poly(Vinyl Chloride) (PVC) Conduit and Fittings for Underground Installation; 2019 (Reapproved 2024).
- E ASTM F2160 - Standard Specification for Solid Wall High Density Polyethylene (HDPE) Conduit Based on Controlled Outside Diameter (OD); 2016.
- F ASTM F2176 - Standard Specification for Mechanical Couplings Used on Polyethylene Conduit, Duct and Innerduct; 2017.
- G BICSI ITSIMM - Information Technology Systems Installation Methods Manual (ITSIMM), 8th Edition; 2022.
- H BICSI TDMM - Telecommunications Distribution Methods Manual, 14th Edition; 2020.
- I NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.
- J NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; 2020.
- K NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; 2021.
- L NEMA TC 6&8 - Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installations; 2020.
- M NEMA TC 7 - Solid-Wall Coilable and Straight Electrical Polyethylene Conduit; 2021.
- N NEMA TC 9 - Fittings for Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation; 2020.
- O NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- P TIA-568.0 - Generic Telecommunications Cabling for Customer Premises; 2020e.

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- Q TIA-569 - Telecommunications Pathways and Spaces; 2019e, with Addendum (2022).
- R UL 1 - Flexible Metal Conduit; Current Edition, Including All Revisions.
- S UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.
- T UL 6A - Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel; Current Edition, Including All Revisions.
- U UL 360 - Liquid-Tight Flexible Metal Conduit; Current Edition, Including All Revisions.
- V UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.
- W UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.
- X UL 651A - Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit; Current Edition, Including All Revisions.
- Y UL 746C - Polymeric Materials – Use in Electrical Equipment Evaluations; Current Edition, Including All Revisions.
- Z UL 797 - Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.
- AA UL 797A - Electrical Metallic Tubing - Aluminum and Stainless Steel; Current Edition, Including All Revisions.
- BB UL 1242 - Electrical Intermediate Metal Conduit-Steel; Current Edition, Including All Revisions.
- CC UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit; Current Edition, Including All Revisions.
- DD UL 2024 - Standard for Cable Routing Assemblies and Communications Raceways; Current Edition, Including All Revisions.
- EE UL 2419 - Outline of Investigation for Electrically Conductive Corrosion Resistant Compounds; Current Edition, Including All Revisions.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordination:

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1. Coordinate minimum sizes of conduits with actual type and quantity of cables to be installed.
2. Coordinate arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts.
3. Verify exact conduit termination locations required for boxes, enclosures, and equipment.
4. Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.
5. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B Sequencing:

1. Do not begin installation of communications cables until installation of conduit between termination points is complete.

1.5 SUBMITTALS

A See Section 013000 - Administrative Requirements for submittals procedures.

B Shop Drawings:

1. Indicate proposed arrangement for conduits to be installed within structural concrete slabs, where permitted.
2. Include proposed locations of roof penetrations and methods for sealing.

C Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2-inch (53 mm) trade size and larger.

1.6 QUALITY ASSURANCE

A Documents at Project Site: Maintain at project site one copy of manufacturer's instructions and shop drawings.

1.7 DELIVERY, STORAGE, AND HANDLING

A Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 CONDUIT APPLICATIONS

A Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, TIA-569, BICSI ITSIMM, BICSI TDMM, manufacturers' instructions, and product listing.

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- B Unless otherwise indicated and where not otherwise restricted, use conduit types indicated for specified applications. Where more than one listed application applies, comply with most restrictive requirements. Where conduit type for particular application is not specified, use galvanized steel rigid metal conduit.
- C Embedded Within Concrete:
1. Within Slab on Grade: Use rigid PVC conduit. Embed within structural slabs only where approved by Structural Engineer.
 2. Within Slab Above Ground: Use rigid PVC conduit. Embed within structural slabs only where approved by Structural Engineer.
- D Concealed Within Hollow Stud Walls: Use electrical metal tubing (EMT).
- E Concealed Above Accessible Ceilings: Use electrical metal tubing (EMT).
- F Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), or galvanized steel electrical metallic tubing (EMT).
- G Exposed, Interior, Not Subject to Physical Damage: Use electrical metal tubing.
- H Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or stainless steel intermediate metal conduit (IMC).
1. Locations subject to physical damage include, but are not limited to:
 - a. Where exposed below 8 feet (2.4 m), except within electrical and communication rooms or closets.
 - b. Where exposed below 20 feet (6.1 m) in warehouse areas.
- I Exposed, Interior, Subject to Severe Physical Damage: Use galvanized steel rigid metal conduit (RMC) or stainless steel rigid metal conduit (RMC).
1. Locations subject to severe physical damage include, but are not limited to:
 - a. High traffic industrial and warehouse areas where exposed below 8 feet (2.4 m), except within electrical and communication rooms or closets.
 - b. Where exposed below 20 feet (6.1 m) in industrial manufacturing areas.
- J Exposed, Exterior, Not Subject to Severe Physical Damage: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), galvanized steel electrical metallic tubing (EMT), or stainless steel electrical metallic tubing (EMT).
- K Exposed, Exterior, Subject to Severe Physical Damage: Use galvanized steel rigid metal conduit (RMC) or stainless steel rigid metal conduit (RMC).
1. Exterior locations subject to severe physical damage include, but are not limited to:

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- a. Where exposed to vehicular traffic below 20 feet (6.1 m).
- L Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), or galvanized steel electrical metallic tubing (EMT).
- M Corrosive Locations Above Ground: Use stainless steel rigid metal conduit (RMC) or stainless steel intermediate metal conduit (IMC).
 - 1. Corrosive locations include, but are not limited to:
 - a. Cooling towers.
 - b. Electroplating operations.
 - c. Swimming pools and associated equipment areas.
 - d. Wastewater treatment facilities.
 - e. Marine environments.
 - f. Chemical storage areas.
- N Hazardous/Classified Locations: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or stainless steel intermediate metal conduit (IMC).
- O Flexible 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 (1.8 m) unless otherwise indicated.
 - 4. Vibrating equipment includes, but is not limited to:
 - a. Motorized equipment.

2.2 CONDUIT - GENERAL REQUIREMENTS

- A Comply with NFPA 70 and TIA-569.
- B Provide conduit, fittings, supports, and accessories required for complete communications pathway.
- C Provide products listed, classified, and labeled as suitable for purpose intended.
- D Where conduit size is not indicated, size to comply with NFPA 70, TIA-569, and BICSI TDMM, but not less than applicable minimum size requirements specified. Where specified standards differ, comply with most stringent.

2.3 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

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- A Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- B Fittings:
1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6.
 2. Material: Use steel or malleable iron.
 3. Connectors and Couplings: Use threaded fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.
 4. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.4 STAINLESS STEEL RIGID METAL CONDUIT (RMC)

- A Description: NFPA 70, Type RMC stainless steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6A.
- B Fittings:
1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6A.
 2. Material: Use stainless steel with corrosion resistance equivalent to conduit.
 3. Connectors and Couplings: Use threaded fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.
 4. Conduit Bodies: Standard conduit bodies designed for electrical raceways are not permitted.

2.5 GALVANIZED STEEL INTERMEDIATE METAL CONDUIT (IMC)

- A Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B Fittings:
1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 1242.
 2. Material: Use steel or malleable iron.
 3. Connectors and Couplings: Use threaded fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.
 4. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.6 STAINLESS STEEL INTERMEDIATE METAL CONDUIT (IMC)

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- A Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B Fittings:
 - 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 1242.
 - 2. Material: Use stainless steel with corrosion resistance equivalent to conduit.
 - 3. Connectors and Couplings: Use threaded fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.
 - 4. Conduit Bodies: Standard conduit bodies designed for electrical raceways are not permitted.

2.7 FLEXIBLE METAL CONDUIT (FMC)

- A 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.
- B Fittings:
 - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - 3. Conduit Bodies: Standard conduit bodies designed for electrical raceways are not permitted.

2.8 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.
- B Fittings:
 - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - 3. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.9 GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)

- A Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- B Fittings:

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1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel or malleable iron.
3. Connectors and Couplings: Use compression/gland or set-screw type.
 - a. Do not use indenter type connectors and couplings.
4. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.10 STAINLESS STEEL ELECTRICAL METALLIC TUBING (EMT)

- A Description: NFPA 70, Type EMT stainless steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797A.
- B Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use stainless steel with corrosion resistance equivalent to conduit.
 3. Connectors and Couplings: Use compression/gland or set-screw type.
 4. Conduit Bodies: Standard conduit bodies designed for electrical raceways are not permitted.

2.11 ALUMINUM ELECTRICAL METALLIC TUBING (EMT)

- A Description: NFPA 70, Type EMT aluminum electrical metallic tubing listed and labeled as complying with UL 797A.
- B Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B; listed for use with aluminum EMT.
 2. Material: Use aluminum.
 3. Connectors and Couplings: Use compression/gland or set-screw type.
 - a. Do not use indenter type connectors and couplings.
 4. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.12 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

- A 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.

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B 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.
3. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.13 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)

- A Description: NFPA 70, Type LFNC liquidtight flexible nonmetallic conduit listed and labeled as complying with UL 1660.

B 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 type of conduit to be connected.

2.14 HIGH-DENSITY POLYETHYLENE (HDPE) CONDUIT

- A Manufacturers:

- B Description: NFPA 70, Type HDPE high-density polyethylene solid-wall conduit complying with ASTM F2160 and NEMA TC 7; list and label as complying with UL 651A; Schedule 40 unless otherwise indicated.

- C Joining Methods: Approved by HDPE conduit manufacturer.

- D Mechanical Fittings: Comply with ASTM F2176; list and label as complying with UL 651A.

2.15 POLYVINYL CHLORIDE (PVC) PLASTIC UTILITIES DUCT

- A Description: Rigid polyvinyl chloride plastic utilities duct complying with NEMA TC 6&8 and ASTM F512; Type EB-20 listed and labeled as complying with UL 651 suitable for burial with concrete encasement.

- B Fittings: Comply with NEMA TC 9.

1. Manufacturer: Same as manufacturer of duct to be connected.

2.16 INSIDE-PLANT FLEXIBLE NONMETALLIC COMMUNICATIONS RACEWAY/INNERDUCT

- A Manufacturers:

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- B Description: Flexible, corrugated, nonmetallic communications raceway and associated fittings listed and labeled as complying with UL 2024; also suitable for installation as innerduct.
- C Raceway Applications:
 - 1. Plenum Applications: Use listed plenum raceway.
 - 2. Riser Applications: Use listed riser or plenum raceway.
 - 3. General Purpose Applications: Use listed general purpose, riser, or plenum raceway.
- D Use only with approved cables in accordance with listing.
- E Color: Orange, unless otherwise indicated.

2.17 ACCESSORIES

- A Inside-Plant Fabric Innerduct:
 - 1. Listed as complying with UL 2024; plenum rated.
 - 2. Products:
 - a. MaxCell Innerduct; MaxCell Premise: www.maxcell.us/#sle.
- B Outside-Plant Fabric Innerduct:
 - 1. Designed for installation in underground raceways.
 - 2. Detectable Innerduct:
 - a. Includes integral, magnetic detectable tracer wire, minimum 18 AWG copper.
 - b. Provide NFPA 70 required bonding of metal components in accordance with manufacturer written instructions.
 - 3. Products:
 - a. MaxCell Innerduct; MaxCell Edge: www.maxcell.us/#sle.
- C Outside-Plant HDPE Innerduct: Smooth interior wall; orange unless otherwise indicated.
 - 1. Products:
 - a. ABB; Carlon; _____
 - b. Blue Diamond Industries, LLC; _____
 - c. Dura-Line; _____
- D Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil, 0.020 inch (0.51 mm).
- E Conduit Joint Compound: Corrosion-resistant, electrically conductive compound listed as complying with UL 2419; suitable for use with conduit to be installed.
- F Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.

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- G Adhesive for HDPE and RTRC Conduit:
1. Specifically designed for bonding dissimilar materials in lieu of transition fittings, including but not limited to polyethylene, fiberglass, PVC, aluminum, and steel; UL 746C recognized.
 2. Approved by adhesive manufacturer for use with materials to be joined.
- H Pull Strings: Use nylon or polyester tape with average breaking strength of not less than 1,250 lbf (5.6 kN).
- I Foam Conduit Sealant:
1. Removable, two-part, closed-cell foam, specifically designed for sealing conduit openings against water, moisture, gases, and dust.
 2. Suitable for use with conductors/cables and associated insulation/jackets to be installed.
 3. Rated to hold minimum of 10 ft (3.0 m) water head pressure.
- J Sealing Compound for Hazardous/Classified Location Sealing Fittings: Listed for use with particular fittings to be installed.
- K Sealing Systems for Concrete Penetrations:
1. Sleeves: Provide water stop ring or cement coating that bonds to concrete to prevent water infiltration.
 2. Rate for minimum of 40 psig; suitable for sealing around conduits to be installed.
- L 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.
- M 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.
- N Duct Bank Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for concrete encasement in open trench installation; suitable for conduit/duct arrangement to be installed.
- O Bore Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for installation within casing; furnished with roller wheels to facilitate installation, openings to facilitate grout flow, and holes for stabilization cable; suitable for casing and conduit/duct arrangement to be installed.

END OF SECTION 270533.13 270533.13

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SECTION 270536
CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Metal cable tray systems:
 - 1. Metal ladder cable tray.
 - 2. Metal wire mesh/basket cable tray.

1.2 RELATED REQUIREMENTS

- A Section 078400 - Firestopping.
- B Section 270529 - Hangers and Supports for Communications Systems.
- C Section 271000 - Structured Cabling: General structured cabling system requirements.

1.3 REFERENCE STANDARDS

- A ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- B ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2023.
- C NEMA VE 1 - Metal Cable Tray Systems; 2017.
- D NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 ADMINISTRATIVE REQUIREMENTS

- A Coordination:
 - 1. Coordinate arrangement of cable tray with structural members, ductwork, piping, equipment and other potential conflicts. Coordinate work to avoid installation of obstructions within cable tray required clearances.
 - 2. Coordinate arrangement of cable tray with dimensions and clearance requirements of actual products to be installed.

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3. Coordinate work with placement of supports and anchors required for mounting.
 4. Notify of 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; require attendance of affected installers. Review proposed routing, sequence of installation, and protection requirements for installed cable tray.
- C Sequencing:
1. Do not begin installation of cables until installation of associated cable tray run is complete.

1.5 SUBMITTALS

- A See Section 271000 for additional submittal requirements.
- B Product Data: Provide manufacturer's standard catalog pages and data sheets for cable tray system components and accessories. Include dimensions, materials, fabrication details, finishes, and span/load ratings.
- C Shop Drawings: Include dimensioned plan views and sections indicating proposed cable tray routing, required clearances, and locations and details of supports, fittings, building element penetrations, and equipment connections.
- D Project Record Documents: Record actual routing of cable tray and locations of supports.

1.6 QUALITY ASSURANCE

- A See Section 271000 for additional quality assurance requirements.
- B Comply with NFPA 70.
- C Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

1.7 DELIVERY, STORAGE, AND HANDLING

- A Handle products carefully to avoid damage to finish.

PART 2 PRODUCTS

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2.1 CABLE TRAY SYSTEM - GENERAL REQUIREMENTS

- A Provide new cable tray system consisting of required components, fittings, supports, and accessories, as necessary for complete system.
- B Provide products listed, classified, and labeled as suitable for purpose intended.
- C Do not use cable tray for applications other than as permitted by NFPA 70 and product listing/classification.
- D Provide cable tray system and associated components suitable for use at indicated span/load ratings under service conditions at installed location.
- E Unless otherwise indicated, specified span/load ratings are based on safety factor of 1.5 and working load only (i.e., no additional concentrated static load), with ratings for metal cable tray systems in accordance with NEMA VE 1.
- F Unless otherwise indicated, specified load/fill depths and inside widths are nominal values, with values for metal cable tray systems in accordance with NEMA VE 1 including applicable allowable tolerances.
- G See Section 271000 for additional requirements for communications systems design and pathways.

2.2 METAL CABLE TRAY SYSTEMS

- A Manufacturers:
 - 1. B-Line
 - 2. Cablofil, a brand of Legrand North America, Inc
 - 3. Eaton
 - 4. Hubbel
 - 5. nVent
 - 6. Source Limitations: Furnish cable tray system and associated components and accessories produced by single manufacturer and obtained from single supplier.
- B Comply with NEMA VE 1.
- C Material/Finishes:
 - 1. Zinc Electroplated Steel: Comply with ASTM B633.
 - 2. Mill-Galvanized Before Fabrication (Pre-Galvanized) Steel: Comply with ASTM A653/A653M, G90 coating.

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D Metal Ladder Cable Tray:

1. Material: Powder Coated Finish, Black. Unless Otherwise Noted
2. Side Rail Construction: Steel Tube
3. Span/Load Rating: As indicated on drawings.
4. Rung Spacing: 9 inches (229 mm) on center for straight lengths.
5. Inside Width: As indicated on drawings.
6. Inside Radius of Fittings: 12 inches (305 mm).
7. Products:
 - a. Chatworth UL Classified Cable Runway
 - b. Hubbell NEXTFRAME Ladder Tray
 - c. Legrand Tubular Runway

E Metal Wire Mesh/Basket Cable Tray:

1. Material: Zinc-electroplated steel or mill-galvanized before fabrication (pre-galvanized) steel.
2. Tray Depth: As indicated on drawings.
3. Span/Load Rating: As indicated on drawings.
4. Mesh Spacing: 2 by 4 inches (51 by 102 mm).
5. Tray Width: As indicated on drawings.
6. Products:
 - a. Eaton Flextray
 - b. Legrand Cablofil Tray-EZ
 - c. nVent WBT

2.3 SOURCE QUALITY CONTROL

A See Section 014000 - NOT OEC EDITED - Quality Requirements for additional requirements.

B Metal Cable Tray: Perform factory design tests in accordance with NEMA VE 1, including electrical continuity and load testing.

END OF SECTION 270536 270536

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SECTION 271000
STRUCTURED CABLING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Copper cable and terminations.
- B Fiber optic cable and interconnecting devices.
- C Communications outlets.
- D Communications identification.

1.2 REFERENCE STANDARDS

- A BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition; 2019.
- B ICEA S-90-661 - Category 3 and 5E Individually Unshielded Twisted Pairs, Indoor Cables (With or Without an Overall Shield) for Use in General Purpose and LAN Communication Wiring Systems; 2021.
- C NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D TIA-455-21 - FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices; 1988a (Reaffirmed 2012).
- E TIA-526-7 - Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Adoption of IEC 61280-4-2 Edition 2: Fibre-Optic Communications Subsystem Test Procedures – Part 4-2: Installed Cable Plant – Single-Mode Attenuation and Optical Return Loss Measurement; 2015a (Reaffirmed 2022).
- F TIA-526-14 - Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant; IEC 61280-4.1 Edition 3.1, Fiber Optic Communications Subsystem Test Procedures- Part 4-1: Installed Cable Plant- Multimode Attenuation Measurement; 2023d.
- G TIA-568 (SET) - Commercial Building Telecommunications Cabling Standard Set; 2024.

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- H TIA-568.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standards; 2018d, with Addenda (2020).
- I TIA-568.3 - Optical Fiber Cabling and Components Standard; 2022e.
- J TIA-569 - Telecommunications Pathways and Spaces; 2019e, with Addendum (2022).
- K TIA-598 - Optical Fiber Cable Color Coding; 2014d, with Addendum (2018).
- L TIA-606 - Administration Standard for Telecommunications Infrastructure; 2021d.
- M TIA-607 - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises; 2019d, with Addendum (2021).
- N UL 444 - Communications Cables; Current Edition, Including All Revisions.
- O UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers; Current Edition, Including All Revisions.
- P UL 1863 - Communications-Circuit Accessories; Current Edition, Including All Revisions.

1.3 SUBMITTALS

- A Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.
- B 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).
- C Evidence of qualifications for installer.
- D Field Test Reports.
- E 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.

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- F 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.

1.4 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.

1.5 DELIVERY, STORAGE, AND HANDLING

- A Store products in manufacturer's unopened packaging until ready for installation.
- B Keep stored products clean and dry.

1.6 WARRANTY

- A Correct defective Work within a 2 year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.1 COPPER CABLE AND TERMINATIONS

- A Manufacturers:
1. Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

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- B Copper Backbone Cable:**
1. Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).
 2. Cable Capacity: Quantity of pairs as indicated on drawings.
 3. Cable Applications:
 - a. Plenum Applications: Use listed NFPA 70 Type CMP plenum cable.
 - b. Riser Applications: Use listed NFPA 70 Type CMR riser cable or Type CMP plenum cable.
- C Copper Horizontal Cable:**
1. Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).
 2. Cable Capacity: 4-pair.
 3. Cable Applications:
 - a. Plenum Applications: Use listed NFPA 70 Type CMP plenum cable.
 - b. Riser Applications: Use listed NFPA 70 Type CMR riser cable or Type CMP plenum cable.
 - c. General Purpose Applications: Use listed NFPA 70 Type CM/CMG general purpose cable, Type CMR riser cable, or Type CMP plenum cable.
- D Jacks and Connectors:**
1. Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).
 2. Performance: 500 mating cycles.
 3. Voice and Data Jacks: 8-position modular jack, color-coded for both T568A and T568B wiring configurations.
- E Copper Patch Cords:**
1. Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).
 2. Description: Factory-fabricated 4-pair cable assemblies with 8-position modular connectors terminated at each end. Connector shall have snagless design. Product shall be provided by the manufacturer of the copper jacks and connectors.
 3. Patch Cords for Patch Panels:
 - a. Quantity: One for each patch panel ports terminated with a Work Area cable.
 - b. Length: Coordinate with WSU C&IT.
 4. Patch Cords for Work Areas:
 - a. Quantity: One for each work area outlet port.
 - b. Length: Coordinate with WSU C&IT.
 5. Product(s):
 - a. As manufactured by the manufacturer of the copper connector solution being provided and matching the performance parameters of the terminations for which the patch cord is being provided.

2.2 FIBER OPTIC CABLE AND INTERCONNECTING DEVICES

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- A Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).
- B Fiber Optic Backbone Cable:
 - 1. Cable Capacity: Quantity of fibers as indicated on drawings.
 - 2. Cable Applications:
 - a. Plenum Applications: Use listed NFPA 70 Type OFNP plenum cable.
 - b. Riser Applications: Use listed NFPA 70 Type OFNR riser cable or Type OFNP plenum cable.
 - 3. Cable Jacket Color:
 - a. Laser-Optimized Multimode Fiber (OM3/OM4): Aqua.
 - b. Multimode Fiber (OM1/OM2): Orange.
 - c. Single-Mode Fiber (OS1/OS2): Yellow.
 - 4. Environmental Rating
 - a. Indoor
 - b. Outdoor
 - c. Indoor/Outdoor
 - 5. Performance Rating
 - a. Single Mode: OS2
 - b. Multi-mode: OM4
- C Fiber Optic Interconnecting Devices:
 - 1. Connector Type: Type LC.
 - 2. Connector Performance: 500 mating cycles, when tested in accordance with TIA-455-21.
 - 3. Maximum Attenuation/Insertion Loss: 0.3 dB.
- D Fiber Optic Patch Cords:
 - 1. Description: Factory-fabricated 2-fiber cable assemblies with suitable connectors at each end.
 - 2. Patch Cords for Patch Panels:
 - a. Quantity: One for each pair of patch panel ports.
 - b. Length: Coordinate with WSU C&IT.

2.3 COMMUNICATIONS OUTLETS

- A Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).
- B Wall Plates:
 - 1. Comply with system design standards and UL 514C.
 - 2. Accepts modular jacks/inserts.
 - 3. Capacity: As indicated on the e Drawings.
 - 4. Wall Plate Material/Finish - Flush-Mounted Outlets: Match wiring device and wall plate finishes specified in Section 262726.

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5. Wall Plate Material/Finish - Flush-Mounted Outlets: Match wiring device and wall plate finishes specified on the drawings.
6. Wall Plate Material/Finish - Flush-Mounted Outlets: High impact thermoplastic, color to be selected.

2.4 IDENTIFICATION PRODUCTS

- A Comply with TIA-606.

2.5 SOURCE QUALITY CONTROL

- A Factory test cables according to TIA-568 (SET).

PART 3 EXECUTION

3.1 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.

3.2 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. In Telecommunications Rooms and Telecommunications Enclosures: 120".
 2. At Outlets - Copper: 12"
 3. At Outlets - Optical Fiber: 48".
- C Copper Cabling:
1. Category 5e and Above: Maintain cable geometry; do not untwist more than 1/2 inch (12.7 mm) from point of termination.
 2. For 4-pair cables in conduit, do not exceed 25 pounds (110 N) pull tension.
 3. Use T568B wiring configuration.

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- D Fiber Optic Cabling:
 - 1. Prepare for pulling by cutting outer jacket for 10 inches (254 mm) from end, leaving strength members exposed. Twist strength members together and attach to pulling eye.
 - 2. Support vertical cable at intervals as recommended by manufacturer.
- E Floor-Mounted Racks and Enclosures: Permanently anchor to floor in accordance with manufacturer's recommendations.
- F Floor-Mounted Enclosures: Connect adjacent cabinets together and remove interior side panels.
- G Identification:
 - 1. Use machine generated pre printed labels 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.

3.3 FIELD QUALITY CONTROL

- A Comply with inspection and testing requirements of specified installation standards.
- B 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.
- C 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 3 Backbone: Perform attenuation test.
 - 5. Category 3 Links: Test each pair for short circuit continuity, short to ground, crosses, reversed polarity, operational and ring-back, and dial tone.
 - 6. Category 5e and Above Backbone: Perform near end cross talk (NEXT) and attenuation tests.
 - 7. Category 5e and Above Links: Perform tests for wire map, length, attenuation, NEXT, and propagation delay.
- D Testing - Fiber Optic Cabling:

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1. Backbone: Perform optical fiber end-to-end attenuation test using an optical time domain reflectometer (OTDR) and manufacturer's recommended test procedures; perform verification acceptance tests and factory reel tests.
 2. Multimode Backbone: Perform tests in accordance with TIA-526-14.
 3. Single Mode Backbone: Perform tests in accordance with TIA-526-7.
 4. Links: Perform optical fiber end-to-end attenuation tests and field reel tests.
- 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 271000

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SECTION 271500
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 GENERAL

1.1 DESCRIPTION

- A Provide equipment cabinets, racks, wire management, and related accessories. Refer to drawing plans for cable locations and quantities.

1.2 SECTION INCLUDES

- A Equipment racks and cabinets.
- B Horizontal and vertical wire management hardware.
- C Power strips.

1.3 REFERENCE STANDARDS

- A EIA/ECA-310 - Cabinets, Racks, Panels, and Associated Equipment; 2005e.
- B NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.4 RELATED DOCUMENTS

- A Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

1.5 SUBMITTALS

- A Product Data.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

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- A Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

2.2 MATERIALS

A General

1. Provide accessories as detailed herein and on plans, drawings and sketches.
2. Cabinets/racks shall meet or exceed the following:
 - a. Aluminum or steel construction.
 - b. Meet or exceed ECIA EIA/ECA-310-E standards.
 - c. All cabinets/racks shall be from one (1) manufacturer. Substitution of parts is not acceptable.
 - d. Contain all parts and accessories as shown on Drawings, and any additional fittings and components as required for a complete installation.

B Equipment Racks

1. General
 - a. Ground bus bar equipped.
2. Communications Equipment Rack
 - a. 2-post or 4-post, as indicated on the drawings.

C Horizontal Cable and Wire Management

1. Horizontal wire management shall be a singular and independent unit, and not integrated into cross-connect or other cabinet and rack mounted equipment.

D Vertical Cable and Wire Management

1. Provide and install full length covers/lids on all vertical cable and wire management channels.
2. Racks
 - a. Shall run the full external height of rack.

E Power Strips

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. LED indicator lights for power and protection status.
3. LED indicator lights for reverse polarity and open outlet ground.
4. Rocker-type on-off switch, illuminated when in on position.
5. Close-coupled, direct plug-in line cord.

PART 3 EXECUTION

3.1 INSTALLATION

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- A Securely support all cables entering or exiting cabinet/rack with appropriate cable management equipment to relieve excessive strain and tension on the cables and to dress the cables in a neat, workmanship-like manner in strict accordance with industry-wide standards.
- B Vacuum clean cabinet/rack, and dust all exposed surfaces upon completion of installation.
- C Permanently fasten cabinet/rack to floor except in locations where cabinet casters are specified or where wall mounting is indicated.
- D Securely fasten cabinets/racks together with approved ganging kits where multiple cabinets/racks are installed, except when casters are specified. See Drawings and details.
- E Grounding and Bonding
 - 1. Cabinet/rack shall be grounded and bonded by means of a grounding conductor to an approved grounding electrode provided by others.
 - 2. Ground cabinets/racks directly to grounding electrode.
 - 3. Grounding equipment/material shall be attached to an unpainted exposed metallic section of cabinet/rack.
 - 4. Ground equipment/material (screw, lug, Burndy, etc.) shall be bare metal on conducting surfaces.
 - 5. Grounding conductor shall be minimum 6 AWG and bare copper or jacketed with green coloring.
 - a. Label all grounding conductors "Telecommunications Ground, Do Not Remove" at each end.
- F Verify final placement of cabinets/racks with Architect prior to installation.
- G Contractor shall provide cabinets/racks with all necessary cable management, mounting rails, grounding kits, fittings, and accessories for a complete installation.
- H Provide and install size and quantity as indicated on Drawings.
- I Cable and Wire Management
 - 1. Attach cable and wire management to cabinets and racks per manufacturer guidelines.
 - 2. Install vertical cable and wire management on both sides of each cabinet and rack, unless noted otherwise.

3.2 WARRANTY

- A As indicated in Section 271000.

END OF SECTION 271100 271500

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SECTION 281000
ACCESS CONTROL SYSTEM

PART 1 GENERAL

1.1 REQUIREMENTS

- A Provide system cables, devices, and equipment that allows for access control and monitoring of doors.
- B WSU Public Safety has all authority over all Access Control systems using WSU PD approved and preferred vendors. All Access Control designs and installations must be reviewed and approved by WSU Public Safety and WSU C&IT Prior to installation.

1.2 SECTION INCLUDES

- A Cables.
- B Card Readers.
- C Controllers.
- D Control Boards.
- E Door Contacts.
- F Reader Boards.
- G Request to Exit and Push Button Release Devices.
- H All equipment as necessary for a complete and functionally installed system.

1.3 RELATED DOCUMENTS

- A Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/ws-u-communications-standards.pdf>).

1.4 SUBMITTALS

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A Product Data.

1.5 QUALITY ASSURANCE

A As indicated in Section 270000.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

2.2 ACCESS CONTROL SYSTEM EQUIPMENT

A Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

PART 3 EXECUTION

3.1 INSTALLATION

A All system programming shall be coordinated with WSU PD and WSU C&IT.

B Install all equipment as indicated on the Drawings, plans, sketches, specifications manual, per Manufacturer's recommendations, and as required for a complete and operational system.

C Coordinate final locations of devices and equipment directly with WSU PD and WSU C&IT prior to installation.

D Cabling and Wires

1. Conceal cables and wires wherever possible.
2. Install cables and wires as recommended by Manufacturer.

3.2 TESTING AND ADJUSTMENTS

A Fully complete system installation prior to testing.

B Initial Testing

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1. Conduct an initial test of the system. During the course of this test, place the entire system in service, including all integrated devices, and calibrate and test all equipment.
2. Correct and note any deficiencies found during testing.
3. Provide Owner and Architect with a written report on the results of initial testing.

C Testing Completion.

1. Correct all anomalies, deficiencies, and failures identified in initial testing.
2. Perform final calibration of the system.
3. Verify in writing to Owner and Architect the system has been calibrated, tested and is fully functional as specified herein.

3.3 RECORD DOCUMENTS

- A As indicated in Section 270000.

3.4 WARRANTY

- A As indicated in Section 270000.

END OF SECTION 281000

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SECTION 282000
VIDEO SURVEILLANCE

PART 1 GENERAL

1.1 REQUIREMENTS

- A Provide system cables, devices, and equipment that captures images, transmits video signals, processes and records video, and allows for video monitoring.
- B WSU Public Safety has all authority over all Video Surveillance systems using WSU PD approved and preferred vendors. All Video Surveillance designs and installations must be reviewed and approved by WSU Public Safety and WSU C&IT Prior to installation.

1.2 SECTION INCLUDES

- A Cables.
- B Cameras.
- C Camera Licenses.
- D Camera Mounts.
- E Camera Mounting Hardware.
- F Power Supplies.
- G Video Recorders.
- H Video Storage.
- I All equipment as necessary for a complete and functionally installed system.

1.3 RELATED DOCUMENTS

- A Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

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1.4 SUBMITTALS

- A Product Data.

1.5 QUALITY ASSURANCE

- A As indicated in Section 270000.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

2.2 VIDEO SURVEILLANCE SYSTEM EQUIPMENT

- A Comply with Wayne State University Standards for Telecommunications Infrastructure (<https://tech.wayne.edu/docs/wsu-communications-standards.pdf>).

PART 3 EXECUTION

3.1 INSTALLATION

- A All system programming shall be coordinated with WSU PD and WSU C&IT.
- B Install all equipment as indicated on Drawings, plans, sketches, specifications manual or as required for a complete and operational system.
- C Coordinate final locations of security devices and equipment directly with the WSU PD and WSU C&IT prior to installation.
- D Camera type, location, enclosure and mounting requirements shall be as indicated on the drawings.
- E Field verify and walk through exact camera location and positioning with WSU PD and WSU C&IT prior to installation.
- F Cabling and Wires
 - 1. Conceal cables and wires wherever possible.

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2. Install cables and wires as recommended by Manufacturer.

3.2 TESTING AND ADJUSTMENTS

- A Fully complete system installation prior to testing.

B Initial Testing

1. Conduct an initial test of the system. During the course of this test, place the entire system in service, including all integrated devices, and calibrate and test all equipment.
2. Correct and note any deficiencies found during testing.
3. Provide Owner and Architect with a written report on the results of initial testing.

C Testing Completion.

1. Correct all anomalies, deficiencies, and failures identified in initial testing.
2. Perform final calibration of the system.
3. Verify in writing to Owner and Architect the system has been calibrated, tested and is fully functional as specified herein.

3.3 RECORD DOCUMENTS

- A As indicted in Section 270000.

3.4 WARRANTY

- A As indicated in Section 270000.

END OF SECTION 282000

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SECTION 283111
NOT OEC EDITED - BUILDING INTRUSION DETECTION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Intrusion detection system requirements.
- B Alarm control units and accessory equipment.
- C Initiating devices.
- D Alarm notification appliances.

PART 2 PRODUCTS

2.1 INTRUSION DETECTION SYSTEM REQUIREMENTS

- A Provide new intrusion detection system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B Alarm Control Unit: New addressable alarm control panel located as indicated.
- C Provide products listed, classified, and labeled as suitable for the purpose intended.
- D Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B, consumer application.

2.2 ALARM CONTROL UNITS AND ACCESSORY EQUIPMENT

- A Alarm Control Panel: Modular construction.
 - 1. Enclosure: Lockable; provide tamper protection.
 - 2. Power Supply:
 - a. Primary Power: 120 VAC; provide suitable transformer/power supply; supervised for loss of AC power.

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- b. Secondary Power: Standby battery; provide suitable capacity for minimum standby time required by listing requirements, applicable codes, and authority having jurisdiction, but not less than four hours; provide suitable battery charger; supervised for low battery condition; protected from accidental reversal of battery leads.
- B Alarm Initiating Circuits: Supervised.
 - 1. Hardwired Zones: Supports both normally closed and normally open conventional (non-addressable) initiating devices.
 - 2. Addressable Zones: Supports addressable initiating devices and modules using multiplexed polling loops.
- C Alarm Notification Circuits: Supervised.
- D Communications Interfaces: Supervised.
 - 1. Supports system reporting to central station receivers via integral interface or accessory interface modules using:
 - a. Telephone lines.
- E Keypads: Supervised.
 - 1. Provide interface to alarm control unit for system control and remote annunciation.
 - 2. Provide visual notification of system status and zone information.
 - 3. Provide audible notification to indicate system status, entry/exit delay, and alarm situations; provide separate distinguishable sounds for alarm and trouble conditions.
 - 4. Keypad Type: Only LCD or graphic touch screen keypads are acceptable. Do not use LED keypads.
 - a. Graphic Touch Screen Keypads: Displays system status and zone information using plain English on graphic display; touch screen interface.
 - b. LCD Keypads: Displays system status and zone information using plain English on alphanumeric display; illuminated keys.
- F Peripheral Devices: Supervised; provide tamper protection.
- G Output Relays:
 - 1. Relay Modules: Form C relays (normally open and normally closed); provide tamper protection.
 - 2. Programmable to respond to system events, according to defined scheduling, or by manual activation from keypad.
- H User Codes:
 - 1. Each user code to be individually assignable to any defined authority level for configurable access to system features and functions.
- I Scheduling:
 - 1. Provide time/calendar-based scheduling capability for automated system control.

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2. Supports open/close schedules for control of arming/disarming and reporting.
3. Supports timed events including, but not limited to:
 - a. Point bypass/unbypass.
 - b. Relay activate/deactivate.

J Event Log:

1. Stores system events including time, date, partition, zone, and user code where applicable.
2. Supports viewing of event log on keypads.

2.3 INITIATING DEVICES

A Manufacturers: Same as manufacturer of alarm control units where possible.

B General Requirements:

1. Provide devices suitable for intended application and location to be installed.
2. Outdoor Units: Weather resistant, suitable for outdoor use.
3. Addressable Systems:
 - a. Addressable Devices: Individually identifiable by control unit.
 - b. Provide suitable addressable modules for connection to conventional (non-addressable) devices and other components that provide a dry closure output.

END OF SECTION 283111

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SECTION 284600
FIRE DETECTION AND ALARM

PART 1 GENERAL

1.1 SECTION INCLUDES

- A Fire alarm system design and installation, including all components, wiring, and conduit.
- B Transmitters for communication with supervising station.
- C Circuits from protected premises to supervising station, including conduit.
- D Replacement and removal of existing fire alarm system components, wiring, and conduit indicated.
- E Maintenance of fire alarm system under contract for specified warranty period.

1.2 RELATED REQUIREMENTS

- A Division 07 - Firestopping: Materials and methods for work to be performed by this installer.
- B Designed using manufacturer's product-specific design software or based on manufacturer's pre-engineered design suitable for the application.
- C Division 08 - Door Hardware: Electrically operated locks and door holder devices to be monitored and released by fire alarm system.
- D Division 14 - Electric Traction Elevators: Elevator systems monitored and controlled by fire alarm system.
- E Section 211300 - Fire-Suppression Sprinkler Systems: Supervisory, alarm, and actuating devices installed in sprinkler system.
- F Section 213000 - Fire Pumps: Supervisory devices.
- G Section 233300 - Air Duct Accessories: Smoke dampers monitored and controlled by fire alarm system.

1.3 REFERENCE STANDARDS

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- A 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines; current edition.
- B ADA Standards - 2010 ADA Standards for Accessible Design; 2010.
- C IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits; 2002 (Corrigendum 2012).
- D NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E NFPA 72 - National Fire Alarm and Signaling Code; Most Recent Edition Cited by Referring Code or Reference Standard.
- F UL 268 - Standard for Smoke Detectors for Fire Alarm Systems; Current Edition, Including All Revisions.

1.4 SUBMITTALS

- A See Section 013000 - Administrative Requirements, for submittal procedures.
- B Evidence of designer qualifications.
- C Design Documents: Submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, and description of operation:
 - 1. Copy (if any) of list of data required by authority having jurisdiction.
 - 2. NFPA 72 "Record of Completion", filled out to the extent known at the time.
 - 3. Clear and concise description of operation, with input/output matrix similar to that shown in NFPA 72 Appendix A-7-5-2.2(9), and complete listing of software required.
 - 4. System zone boundaries and interfaces to fire safety systems.
 - 5. Location of all components, circuits, and raceways; mark components with identifiers used in control unit programming.
 - 6. Circuit layouts; number, size, and type of raceways and conductors; conduit fill calculations; spare capacity calculations; notification appliance circuit voltage drop calculations.
 - 7. List of all devices on each signaling line circuit, with spare capacity indicated.
 - 8. Manufacturer's detailed data sheet for each component, including wiring diagrams, installation instructions, and circuit length limitations.
 - 9. Description of power supplies; if secondary power is by battery include calculations demonstrating adequate battery power.
 - 10. Detailed drawing of graphic annunciator(s).
 - 11. Certification by either the manufacturer of the control unit or by the manufacturer of each other component that the components are compatible with the control unit.

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12. Certification by the manufacturer of the control unit that the system design complies with Contract Documents.
 13. Certification by Contractor that the system design complies with Contract Documents.
- D Evidence of instructor qualifications; training lesson plan outline.
- E Inspection and Test Reports:
1. Submit inspection and test plan prior to closeout demonstration.
 2. Submit documentation of satisfactory inspections and tests.
 3. Submit NFPA 72 "Inspection and Test Form," filled out.
- F Operating and Maintenance Data: See Section 017800 for additional requirements; revise and resubmit until acceptable; have one set available during closeout demonstration:
1. Complete set of specified design documents, as approved by authority having jurisdiction.
 2. Additional printed set of project record documents and closeout documents, bound or filed in same manuals.
 3. Contact information for firm that will be providing contract maintenance and trouble call-back service.
 4. List of recommended spare parts, tools, and instruments for testing.
 5. Replacement parts list with current prices, and source of supply.
 6. Detailed troubleshooting guide and large scale input/output matrix.
 7. Preventive maintenance, inspection, and testing schedule complying with NFPA 72; provide printed copy and computer format acceptable to Owner.
 8. Detailed but easy to read explanation of procedures to be taken by non-technical administrative personnel in the event of system trouble, when routine testing is being conducted, for fire drills, and when entering into contracts for remodeling.
- G Project Record Documents: See Section 017800 for additional requirements; have one set available during closeout demonstration:
1. Complete set of floor plans showing actual installed locations of components, conduit, and zones.
 2. "As installed" wiring and schematic diagrams, with final terminal identifications.
 3. "As programmed" operating sequences, including control events by device, updated input/output chart, and voice messages by event.
- H Closeout Documents:
1. Certification by manufacturer that the system has been installed in compliance with manufacturer's installation requirements, is complete, and is in satisfactory operating condition.
 2. NFPA 72 "Record of Completion", filled out completely and signed by installer and authorized representative of authority having jurisdiction.
 3. Maintenance contract.

1.5 QUALITY ASSURANCE

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- A Designer Qualifications: NICET Level III or IV (3 or 4) certified fire alarm technician or registered fire protection engineer, employed by fire alarm control panel manufacturer, Contractor, or installer , with experience designing fire alarm systems in the jurisdictional area of the authorities having jurisdiction.
- B Installer Qualifications: Firm with minimum 3 years documented experience installing fire alarm systems of the specified type and providing contract maintenance service as a regular part of their business.
 - 1. Authorized representative of control unit manufacturer; submit manufacturer's certification that installer is authorized; include name and title of manufacturer's representative making certification.
 - 2. Installer Personnel: At least 2 years of experience installing fire alarm systems.
 - 3. Supervisor: NICET level III or IV (3 or 4) certified fire alarm technician; furnish name and address.
 - 4. Certified in the State in which the Project is located as fire alarm installer.
- C Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
- D Instructor Qualifications: Experienced in technical instruction, understanding fire alarm theory, and able to provide the required training; trained by fire alarm control unit manufacturer.

1.6 WARRANTY

- A Provide control panel manufacturer's warranty that system components other than wire and conduit are free from defects and will remain so for 1 year after date of Substantial Completion.
- B Provide installer's warranty that the installation is free from defects and will remain so for 1 year after date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A Fire Alarm Control Units and Accessories:
 - 1. Siemens Building Technologies, Inc.
 - 2. Simplex, a brand of Johnson Controls.
 - 3. National Time and Signal.
 - 4. Provide control units made by the same manufacturer.
- B Initiating Devices and Notification Appliances:
 - 1. Siemens Building Technologies, Inc.
 - 2. Simplex, a brand of Johnson Controls.

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3. National Time and Signal.
4. Provide initiating devices and notification appliances made by the same manufacturer, where possible.

2.2 FIRE ALARM SYSTEM

- A Fire Alarm System: Provide a new automatic fire detection and alarm system:
1. Provide all components necessary, regardless of whether shown in Contract Documents or not.
 2. Protected Premises: Entire building shown on drawings.
 3. Comply with the following; where requirements conflict, order of precedence of requirements is as listed:
 - a. ADA Standards.
 - b. The requirements of the State Fire Marshal.
 - c. The requirements of the local authority having jurisdiction .
 - d. Applicable local codes.
 - e. Contract Documents (drawings and specifications).
 - f. NFPA 72; where the word "should" is used consider that provision mandatory; where conflicts between requirements require deviation from NFPA 72, identify deviations clearly on design documents.
 4. Evacuation Alarm: Multiple smoke zones; allow for evacuation notification of any individual zone or combination of zones, in addition to general evacuation of entire premises.
 5. Voice Notification: Provide emergency voice/alarm communications with multichannel capability; digital.
 6. General Evacuation Zones: Each smoke zone is considered a general evacuation zone unless otherwise indicated, with alarm notification in all zones on the same floor, on the floor above, and the floor below.
 7. Program notification zones and voice messages as directed by Owner.
 8. Hearing Impaired Occupants: Provide visible notification devices in all public areas and in dwelling units.
 9. Fire Command Center: Location indicated on drawings.
 10. Fire Alarm Control Unit: New, located at fire command center.
 11. Combined Systems: Do not combine fire alarm system with other non-fire systems.
- B Supervising Stations:
1. Public Fire Department Notification: By on-premises supervising station.
 2. On-Premises Supervising Station: New proprietary station operated by Owner, located at WSU Police Department.
 3. Means of Transmission to On-Premises Supervising Station: Digital alarm communicator transmitter (DACT), dual cellular.
 4. Auxiliary Connection Type: Local energy.
- C Circuits:
1. Initiating Device Circuits (IDC): Class B, Style A.
 2. Signaling Line Circuits (SLC) Within Single Building: Class B, Style 0.5.
 3. Signaling Line Circuits (SLC) Between Buildings: Class A, Style 2.

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4. Notification Appliance Circuits (NAC): Class B, Style W.
5. All circuits from floor to floor shall be 2-hour rated for survivability level 3.
6. All circuits for control and power shall be 2-hour rated.

D Spare Capacity:

1. Initiating Device Circuits: Minimum 20 percent spare capacity.
2. Notification Appliance Circuits: Minimum ____ percent spare capacity.
3. Speaker Amplifiers: Minimum 20 percent spare capacity.
4. Fire Alarm Control Units: Capable of handling all circuits utilized to capacity without requiring additional components other than plug-in control modules.

E Power Sources:

1. Primary: Dedicated branch circuits of the facility power distribution system.
2. Secondary: Storage batteries.
3. Capacity: Sufficient to operate entire system for period specified by NFPA 72.
4. Each Computer System: Provide uninterruptible power supply (UPS).

2.3 FIRE SAFETY SYSTEMS INTERFACES

A Supervision: Provide supervisory signals in accordance with NFPA 72 for the following:

1. Sprinkler water control valves.
2. Fire pump.
3. Elevator shut-down control circuits.
4. Duct smoke detectors.

B Alarm: Provide alarm initiation in accordance with NFPA 72 for the following:

1. Sprinkler water flow and dry sprinkler loss of pressure.
2. Smoke detectors.
3. Heat detectors.
4. Elevator lobby, elevator hoistway, and elevator machine room smoke detectors.

C Elevators:

1. Elevator lobby, hoistway, and machine room smoke detectors: Elevator recall for fire fighters' service.
2. Elevator Machine Room Heat Detector: Shut down elevator power prior to hoistway sprinkler activation if indicated on drawings.
3. Sprinkler pressure or waterflow: Shut down elevator power prior to hoistway sprinkler activation if indicated on drawings.

D HVAC:

1. Duct Smoke Detectors: Close dampers indicated; shut down air handlers indicated.

E Doors:

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1. Smoke Barrier Door Magnetic Holders: Release upon activation of smoke detectors in smoke zone on either side of door.
2. Electromagnetic Door Locks on Egress Doors: Unlock upon activation of any alarm initiating device or suppression system in smoke zone that doors serve as egress from. Refer to Division 08.

2.4 COMPONENTS

A General:

1. Provide flush mounted units where installed in finish areas; in unfinished areas, surface mounted unit are acceptable.
2. Provide legible, permanent labels for each control device, using identification used in operation and maintenance data.

B Fire Alarm Control Units: Analog, addressable type; listed, classified, and labeled as suitable for the purpose intended.

C Remote Annunciators:

1. Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.
 - a. Annunciator and Display: LCD, 80 characters, minimum.
 - b. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

D Addressable Modules:

1. Provide addressable modules suitable for connection to fire alarm control unit signaling line circuits.
2. Unless otherwise indicated, use addressable modules only in clean, dry, indoor, nonhazardous locations.
3. Monitor Modules: Unless devices are explicitly permitted to be connected together as zone, provide separate addressable monitor module for each conventional dry-contact input device in order to be individually identifiable by addressable fire alarm control unit.
4. Control Modules: Provide as indicated or as required for selective control of notification appliances.
5. Releasing Control Modules: Provide as indicated or as required for control of listed solenoids in releasing applications.
6. Relay Modules: Provide as indicated or as required to perform necessary functions via dry-contact interface. Where load exceeds module contact rating, provide accessory power isolation relays suitable for load as required.
7. Signaling Line Circuit (SLC) Isolating Modules: Provide as indicated or as required to automatically isolate short circuits on connected sections of SLC loops and allow other sections to continue to function normally. Provide automatic reset upon correction of short circuit.

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E Initiating Devices:

1. Addressable Systems:
 - a. Addressable Devices: Individually identifiable by addressable fire alarm control unit.
 - b. Provide suitable addressable interface modules as indicated or as required for connection to conventional (non-addressable) devices and other components that provide a dry closure output.
2. Manual Pull Stations:
 - a. Double action mechanism, pull-lever type.
 - b. Provide 1 extra.
3. Smoke Detectors: UL 268.
 - a. Two-wire type.
 - b. Base mounting.
 - c. Self res
 - d. Provide 1 extra.
4. Duct Smoke Detectors: UL 268A.
 - a. Four-wire type.
 - b. Self restoring.
 - c. Weatherproof duct housing enclosure: NEMA 250, Type 4X, listed for use in HVAC ducts.
 - d. Relay fan shutdown.
 - e. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
 - f. Provide 1 extra.
5. Heat Detectors: UL 521.
 - a. Actuated by fixed temperature of 135°F.
 - b. Base lock mounting.
 - c. Provide 1 extra.

F Notification Appliances:

1. Speakers: UL 1480.
 - a. Speakers for voice notification: locate speakers for voice notification to provide intelligibility requirements of "notification appliances" and "emergency communications systems" chapters in NFPA 72.
 - b. Color: White.
 - c. Provide 1 extra.
2. Strobes: UL 1971.
 - a. Rated Light Output: 15/30/75/110 cd, selectable in field.
 - b. Color: White.
 - c. Flashing must be in temporal pattern synchronized with other units.
 - d. Provide 1 extra.

G Circuit Conductors: Copper; provide 200 feet (60 m) extra; color code and label.

H Surge Protection: In accordance with IEEE C62.41.2 category B combination waveform and NFPA 70; except for optical fiber conductors.

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1. Initiating Device Circuits, Notification Appliance Circuits, and Communications Circuits: Provide surge protection at each point where circuit exits or enters a building; rated to protect applicable equipment; for 24 V(dc) maximum dc clamping voltage of 36 V(dc), line-to-ground, and 72 V(dc), line-to-line.
 2. Signaling Line Circuits: Provide surge protection at each point where circuit exits or enters a building, rated to protect applicable equipment.
- I Locks and Keys: Deliver keys to Owner.
1. Provide the same standard lock and key for each key operated switch and lockable panel and cabinet; provide 5 keys of each type
- J Instruction Charts: Printed instruction chart for operators, showing steps to be taken when a signal is received (normal, alarm, supervisory, and trouble); easily readable from normal operator's station.
1. Frame: Stainless steel or aluminum with polycarbonate or glass cover.
 2. Provide one for each control unit where operations are to be performed.
 3. Obtain approval of Owner prior to mounting; mount in location acceptable to Owner.
 4. Provide extra copy with operation and maintenance data submittal.

2.5 FIREFIGHTERS' SMOKE-CONTROL SYSTEM

- A Manufacturers:
1. Siemens.
 2. Simplex.
 3. Graphics National.
 4. The HR Kirland Company.
- B Performance Criteria: NFPA 72 and Ohio Building Code.
- C General Characteristics:
1. Initiate Smoke Management Sequence of Operation:
 - a. Comply with sequence of operations as described on the mechanical drawings and fire alarm sequence of operations.
 - b. Fire alarm system must provide interfaces and control points required to properly activate smoke management systems.
 - c. First fire alarm system initiating device to go into alarm condition must activate smoke control functions.
 - d. Subsequent devices going into alarm condition must have no effect on smoke control mode.
 2. Addressable Relay Modules:
 - a. Provide address setting means on module. Store internal identifying code for control panel use to identify module type.
 - b. Allow control panel to switch relay contacts on command.
 - c. Have minimum of two normally open and two normally closed contacts available for field wiring.

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- d. Listed for controlling HVAC fan motor controllers.

PART 3 EXECUTION

3.1 INSTALLATION

- A Install in accordance with applicable codes, NFPA 72, NFPA 70, and Contract Documents.
- B Conceal all wiring, conduit, boxes, and supports where installed in finished areas.
- C Obtain Owner's approval of locations of devices, before installation.
- D Install instruction cards and labels.

3.2 INSPECTION AND TESTING FOR COMPLETION

- A Notify Owner 7 days prior to beginning completion inspections and tests.
- B Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- C Provide the services of the installer's supervisor or person with equivalent qualifications to supervise inspection and testing, correction, and adjustments.
- D Prepare for testing by ensuring that all work is complete and correct; perform preliminary tests as required.
- E Provide all tools, software, and supplies required to accomplish inspection and testing.
- F Perform inspection and testing in accordance with NFPA 72 and requirements of local authorities; document each inspection and test.
- G Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.
- H Diagnostic Period: After successful completion of inspections and tests, Operate system in normal mode for at least 14 days without any system or equipment malfunctions.
 - 1. Record all system operations and malfunctions.
 - 2. If a malfunction occurs, start diagnostic period over after correction of malfunction.
 - 3. Owner will provide attendant operator personnel during diagnostic period; schedule training to allow Owner personnel to perform normal duties.

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4. At end of successful diagnostic period, fill out and submit NFPA 72 "Inspection and Testing Form."

3.3 OWNER PERSONNEL INSTRUCTION

- A Provide the following instruction to designated Owner personnel:
 1. Hands-On Instruction: On-site, using operational system.
- B Administrative: One-hour session(s) covering issues necessary for non-technical administrative staff; classroom:
 1. Initial Training: 1 session pre-closeout.
- C Basic Operation: One-hour sessions for attendant personnel, security officers, and engineering staff; combination of classroom and hands-on:
 1. Initial Training: 1 session pre-closeout.
- D Furnish the services of instructors and teaching aids; have copies of operation and maintenance data available during instruction.

3.4 CLOSEOUT

- A Closeout Demonstration: Demonstrate proper operation of all functions to Owner.
 1. Be prepared to conduct any of the required tests.
 2. Have at least one copy of operation and maintenance data, preliminary copy of project record drawings, input/output matrix, and operator instruction chart(s) available during demonstration.
 3. Have authorized technical representative of control unit manufacturer present during demonstration.
 4. Demonstration may be combined with inspection and testing required by authority having jurisdiction; notify authority having jurisdiction in time to schedule demonstration.
 5. Repeat demonstration until successful.
- B Occupancy of the project will not occur prior to Substantial Completion.
- C Substantial Completion of the project cannot be achieved until inspection and testing is successful and:
 1. Specified diagnostic period without malfunction has been completed.
 2. Approved operating and maintenance data has been delivered.
 3. All aspects of operation have been demonstrated to Owner.
 4. Final acceptance of the fire alarm system has been given by authorities having jurisdiction.
 5. Specified pre-closeout instruction is complete.

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3.5 MAINTENANCE

- A See Division 01 - Execution and Closeout Requirements for additional requirements relating to maintenance service.
- B Provide to Owner, at no extra cost, a written maintenance contract for entire manufacturer's warranty period, to include the work described below.
- C Perform routine inspection, testing, and preventive maintenance required by NFPA 72, including:
 - 1. Maintenance of fire safety interface and supervisory devices connected to fire alarm system.
 - 2. Repairs required, unless due to improper use, accidents, or negligence beyond the control of the maintenance contractor.
 - 3. Record keeping required by NFPA 72 and authorities having jurisdiction.
- D Provide trouble call-back service upon notification by Owner:
 - 1. Provide on-site response within 2 hours of notification.
 - 2. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 - 3. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- E Provide a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- F Maintain a log at each fire alarm control unit, listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced. Submit duplicate of each log entry to Owner's representative upon completion of site visit.
- G Comply with Owner's requirements for access to facility and security.

END OF SECTION 284600

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SECTION 31000

SITE CLEARING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. CAD files will be made available for use in construction staking. Contact the engineer regarding applicable fee and requirements for signing of the CAD File Transfer Agreement.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Protecting existing trees, shrubs and other vegetation to remain.
 - 2. Removing existing trees, shrubs and other vegetation.
 - 3. Clearing and grubbing.
 - 4. Stripping and stockpiling topsoil.
 - 5. Removing above-grade and below-grade site improvements.
 - 6. Disconnecting, capping or sealing, and abandoning site utilities in place or removing site utilities.
 - 7. Temporary erosion and sedimentation control measures.
- B. Related Sections include the following:
 - 1. Division 31 2000 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
 - 2. Division 32 9200 Section "Turf and Grasses" for finish grading including preparing and placing planting soil mixes and testing of topsoil material.

1.3 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.
- B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

- A. Except for stripped topsoil or other materials indicated to remain on Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site unless otherwise noted on the plans.

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1.5 SUBMITTALS

- A. Photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.
- B. Record drawings, according to Closeout Procedures.
 - 1. Identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 QUALITY ASSURANCE

- A. Preinstallation Conference: Conduct conference at Project site.

1.7 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract. Contractor is to confirm that this authority has been obtained before beginning work on adjoining property.
- C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.
- D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- E. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

- A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 2000 Section "Earth Moving."
 - 1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site. Contractor is responsible for doing an independent earthwork computation and including all necessary import and/or export of materials in their bid.

PART 3 EXECUTION

3.1 PREPARATION

Site Clearing

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- A. Protect and maintain benchmarks and survey control points from disturbance during construction. If said points will be disturbed, establish new points prior to removal.
- B. Locate and clearly flag trees and vegetation to remain or to be relocated.
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to Owner.
- 3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL
 - A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction, Due Care Plan for Construction, and the sediment and erosion control drawings, whichever is more stringent.
 - B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
 - C. Remove erosion and sedimentation controls only after all areas are restored and stabilized.
- 3.3 TREE PROTECTION
 - A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.
 - 1. Do not store construction materials, debris, or excavated material within fenced area.
 - 2. Do not permit vehicles, equipment, or foot traffic within fenced area.
 - 3. Maintain fenced area free of weeds and trash.
 - B. Do not excavate within tree protection zones, unless otherwise indicated.
 - C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
 - 1. Cover exposed roots with burlap and water regularly.
 - 2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
 - 3. Coat cut faces of roots more than 1-1/2 inches in diameter with emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
 - 4. Backfill with soil as soon as possible.
 - D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Landscape Architect.
- 3.4 UTILITIES
 - A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed
 - 1. Arrange with utility companies to shut off indicated utilities.
 - 2. Owner will arrange to shut off indicated utilities when requested by Contractor.

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- B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Engineer not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Engineer's written permission.
 - C. Excavate for and remove underground utilities indicated to be removed.
- 3.5 CLEARING AND GRUBBING
- A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
 - 3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
 - 4. Use only hand methods for grubbing within tree protection zone.
 - B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches and compact each layer to a density equal to adjacent original ground.
- 3.6 TOP SOIL STRIPPING
- A. Remove sod and grass before stripping topsoil.
 - B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Remove subsoil and non-soil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.
 - C. Stockpile top-soil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile topsoil material in locations approved by the Owner or Engineer.
- 3.7 SITE IMPROVEMENTS
- A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.
 - B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 - 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
 - 2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.
- 3.8 DISPOSAL

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- A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, other vegetation and waste materials including trash and debris, and legally dispose of them off Owner's property. Refer to Due Care Plan for Construction for disposal requirements.
 - 1. Burning of materials on project property is prohibited.

END OF SECTION

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SECTION 311012

FINE GRADING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to Bidding and Contract Requirements, and General and Supplemental Requirements which are hereby made a part of this section.
- B. CAD files will be made available for use in construction staking. Contact the engineer regarding applicable fee and requirements for signing of the CAD File Transfer Agreement.

1.2 SUMMARY

- A. Work included: All labor, materials, necessary equipment and services to complete the Fine Grading work, as indicated on the drawings, as specified herein or both, except as for items specifically indicated as not in contract on the plans.
- B. Related work specified elsewhere:
 - 1. Division 31 2000 Section "Earth Moving."
 - 2. Division 32 9200 Section "Turfs and Grasses."

1.3 SITE INSPECTION

- A. The Contractor shall visit the site and acquaint himself with all existing conditions, including the Due Care Plan for Construction. The Contractor shall be responsible for his own subsurface investigations, as necessary, to satisfy requirements of this Section. All subsurface investigations shall be performed only under time schedules and arrangements approved in advance by the Engineer or Owner's Representative.

1.4 UTILITIES

- A. Before starting site operations verify that the earlier Contractors have disconnected all temporary utilities which might interfere with the fine grading work.
- B. Locate all existing, active utility lines traversing the site and determine the requirements for their protection. Preserve in operating condition all active utilities adjacent to or transversing the site that are designated to remain.
- C. Observe rules and regulations governing respective utilities in working under requirements of this section. Adequately protect utilities from damage, remove or relocate as indicated, specified or required. Remove, plug or cap inactive or abandoned utilities encountered in excavation. Record location of active utilities.
- D. Contact "Miss Dig" for existing utilities survey confirmation.

1.5 QUALITY ASSURANCE

- A. Requirements of all applicable building codes and other public agencies having jurisdiction upon the work.

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- B. Primary emphasis should be given to the aesthetic appearance and functioning of berming and swales, as directed by the Landscape Engineer or Owner's Representative. The Contractor shall employ skilled personnel and any necessary equipment to insure that finish grading is smooth, aesthetically pleasing, drains well and is ideal for receiving sod and plant materials.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Existing Soil:
 - 1. Strip existing topsoil for new construction unless otherwise directed by Owner's Representative, free from debris, sod, biodegradable materials and other deleterious materials. The Contractor shall insure that all existing soil has sufficient percolation and surface drainage to support grasses and plant material and that extreme compaction occurs only in areas to receive paving.
 - 2. In areas to receive seed, verify that soil is scarified to depth of 3 inches and that soil contains enough organic matter to support and encourage rooting of seeded lawn.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Job Conditions
 - 1. Dust control: Use all means necessary to prevent dust from construction operations from being a nuisance to adjacent property owners and from damaging finish surfaces on adjacent building, paving, etc. Methods used for dust control are subject to approval by the Engineer or Owner's Representative.
 - 2. Burning: On-site burning will not be permitted.
 - 3. Protection: Use all means necessary to protect curbs, gutters, sprinklers, utilities and vegetation designated to remain, and, in the event of damage, immediately make all repairs, replacements and dressings to damaged plants necessary to the approval of the Landscape Engineer. Contractor shall incur all cost for the replacement of damaged objects and vegetation.

3.2 SCHEDULING

- A. Schedule all work in a careful manner with all necessary consideration for adjoining property owners and the public.
- B. Coordinate schedule with other Contractors to avoid conflicts with their work.

3.3 EXCAVATION

- A. Excavate where necessary to obtain subgrades, percolation and surface drainage as required.
- B. Materials to be excavated are unclassified.

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- C. Remove entirely any existing obstructions after approval by the Engineer's or Owner's Representative.
- D. Remove from site and dispose of debris and excavated material not required per Due Care Plan for Construction.

3.4 GRADING

- A. The Contractor shall establish finished grades as shown on the construction plans and as directed by the Engineer, including areas where the existing grade has been disturbed by other work.
- B. Finished grading shall be smooth, aesthetically pleasing, drain well and ready to receive sod and other plant material to full satisfaction of the Owner's Representative, Engineer and Construction Manager.

3.5 COMPACTION

- A. Compact each layer of fill in designated areas with approved equipment to achieve a maximum density at optimum moisture, AASHTO T 180 - latest edition.
 - 1. Under buildings, roadways, curbs, walks and other paved areas: compaction shall be to a minimum 95% of maximum density.
 - 2. Under landscaped area, compaction shall not exceed 85% of maximum density (if different compaction is indicated on the landscape plans, the compaction indicated on the landscape plans shall override).

3.6 CORRECTION OF GRADE

- A. Bring to required grade levels areas where settlement, erosion or other grade changes occur. Adjust grades as required to carry drainage away from buildings and to prevent ponding around the buildings and on pavements.
- B. Remove all rock or objectionable material larger than 1 inch in any direction prior to commencing landscaping.
- C. Contractor shall be responsible for stabilizing grades by approved methods prior to landscaping and shall be responsible for correction of grades as mentioned above, and cleanup of any wash outs or erosion.

END OF SECTION

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SECTION 311018

SOIL EROSION CONTROL

PART 1 GENERAL

1.1 RELATED REQUIREMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- B. CAD files will be made available for use in construction staking. Contact the engineer regarding applicable fee and requirements for signing of the CAD File Transfer Agreement.

1.2 SUMMARY

- A. The work under this Section includes but not limited to all work necessary for effective soil erosion control in conformance with Part 91, Act 451, PA 1994, the Soil Erosion and Sedimentation Control Act, Michigan Department of Natural Resources Environmental Protection Act guidelines and all pertinent local enforcing agency rules and regulations, having jurisdiction. Regardless of whether or not a permit is required, SESC measures are to be implemented per the plans and specifications and Due Care Plan for Construction.
- B. Related Sections include the following:
 - 1. Division 31 1000 Section "Site Clearing".
 - 2. Division 31 1012 Section "Fine Grading".
 - 3. Division 31 2000 Section "Earth Moving".

1.3 STANDARDS

- A. General: Perform all work under this Section in accordance with all pertinent rules and regulations, including, but not necessarily limited to those mentioned above and these Specifications.
- B. Conflicts: Where provisions of pertinent rules and regulations conflict with these Specifications, the more stringent provisions shall govern. Notify Engineer of conflicts, issues, or concerns in order to obtain direction on how to proceed.

PART 2 PRODUCTS

2.1 SEED, FERTILIZER, AND MULCH

- A. Refer to other Specification Section in Part 3.

PART 3 EXECUTION

3.1 GENERAL

- A. Standards: Provide all materials and promptly take all actions necessary to achieve effective erosion control in accordance with the Soil Erosion and Sedimentation Control

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Act, Michigan Department of Natural Resources guidelines, local enforcing agency guidelines and these Specifications.

- B. Site evaluation: Prior to start of the Work, conduct a field evaluation of the site along with representatives of the Engineer/Architect and the local enforcing agency.
- C. Permits: Confirm with Engineer if Soil Erosion Control Permit has been applied for and/or is necessary. If not, contractor is responsible for submitting for and obtaining all pertinent permits including a Soil Erosion Control Permit from the county or local enforcing agency (if required). Submit the NPDES Notice of Coverage when the soil erosion permit is received if not already done.

3.2 SEEDING AND MULCHING

- A. General
 - 1. All bare soil, unless otherwise required by the Contract Documents, shall be seeded, fertilized and mulched to create a protected condition. Use seed mix as indicated on the plans (if different seed mixes are indicated on the civil and landscape plans, the mix indicated on the landscape plans shall override). Critical areas shall be sodded as approved by the Engineer/Architect and as shown on the plans.
 - 2. Seeding and mulching shall be performed immediately upon completion of a phase or section of the Work or as approved by the Engineer/Architect.
 - 3. In all cases, seeding and mulching shall be performed within thirty (30) calendar days from the time the area was first disturbed.
 - 4. During any period of time which the soil is unprotected, provide erosion control measures as necessary to minimize erosion and to keep any eroded soils on the site and out of ditches, rivers, storm sewers and wetlands.
 - 5. Refer to the plans for notes regarding the use of turf reinforcement matting and/or mulch blankets (on all slopes exceeding 1 vertical to 10 horizontal).
- B. Seed: Seed shall be applied uniformly at a minimum rate of 48 pounds per acre (if different seed mixes or rate are indicated on the landscape plans, the mix indicated on the landscape plans shall override).
- C. Fertilizer: Fertilizer shall be applied uniformly at a minimum rate of 250 pounds per acre (if different rates are indicated on the landscape plans, the rates indicated on the landscape plans shall override).
- D. Mulch: Mulch shall be uniformly applied at a rate of two (2) tons per acre, or equal, on all seeded areas that have a slope of less than 1 vertical to 10 horizontal. Refer to note A5. above for additional slope stabilization requirements. (if different or rates are indicated on the landscape plans, the rates indicated on the landscape plans shall override).

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- E. Refer to Section 32 9400 Landscape Maintenance and Warranty Standards regarding requirements for established lawn.

3.3 DITCH AND RIVERS

- A. When reasonably possible, banks of ditches and rivers disturbed under this Work shall be protected within 24 hours of disturbance, but in no case shall banks be left unprotected more than 7 calendar days.

3.4 STEEP SLOPES

- A. Emulsion
 1. On slopes greater than 10%, but not immediately adjacent to a stream or ditch, use erosion control blankets or turf reinforcement matting to hold seed in place. Refer to plan notes.
- B. Other methods: Chemical self-adhering mulch and other mulch anchoring methods may be used as approved by the Engineer/Landscape Architect.

3.5 SITE IMPROVEMENTS CONSTRUCTION

- A. During construction of the site improvements conform to the following general rules:
 1. Minimize the amount of earth disturbed at any one time.
 2. Establish a construction sequence which includes adequate erosion control.
 3. Provide ground cover, even if only temporary, so as to stabilize an area and minimize erosion.
 4. As much as practicable, direct storm water away from the construction area. Direct diverted storm water to any stable area.
 5. Collect runoff from the site in sediment basins, traps or through filters.
 6. Establish an inspection and maintenance schedule, paying special attention to the beginning of the various stages of construction. Employ a certified storm water operator and keep a log of the soil erosion and sedimentation control measures in accordance with the NPDES requirements.
 7. Keep in mind that the primary objective is to keep the soil on the site.
 8. Once final stabilization of the site is complete, and the governing agency has granted its approval, remove all temporary erosion control structures.
 9. Control site runoff during all periods of site construction to ensure that excess surface runoff does not reach adjacent properties. This is especially critical during stages when the land has been stripped but not yet graded.

3.6 CLEANING

- A. Perform cleaning of all areas affected by work under this section and leave the site in a neat and tidy state. Contractor shall keep Adjacent Roads clean and free of debris.

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- B. Contractor is responsible for removal of all temporary soil erosion control measures once vegetation has established and the local governing agency has approved the removal of the temporary measures.

END OF SECTION

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SECTION 312000

EARTH MOVING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. All earthwork operations shall conform to the current Michigan Department of Transportation standards and specifications.
- C. CAD files will be made available for use in construction staking. Contact the engineer regarding applicable fee and requirements for signing of the CAD File Transfer Agreement.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Preparing subgrades for slabs-on-grade, walks, pavements, lawns, and plantings.
 - 2. Subbase course for concrete walks and pavements.
 - 3. Base course for asphalt paving.
 - 4. Excavation and backfill for utility trenches.
- B. Related Sections include the following:
 - 1. Division 31 1000 Section "Site Clearing" for site stripping, grubbing, removing topsoil, and protecting trees to remain.
 - 2. Division 33 4100 Section "Storm Sewers, Underdrains and Drainage Structures" for storm drainage system.

1.3 DEFINITIONS

- A. Backfill: Soil materials used to fill an excavation.
- B. Base Course: Layer placed between the subbase course and asphalt paving.
- C. Bedding Course: Layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Layer supporting slab-on-grade used to minimize capillary flow of pore water.
- F. Engineered Fill: Fill placed and compacted to densities specified herein, in a controlled manner using lift thickness limited herein, monitored and tested by the Testing Agency or independent Geotechnical Inspector.
- G. Excavation: Removal of material encountered above subgrade elevations.
- H. Fill: Soil materials used to raise existing grades.
- I. Rock: Rock material in beds, ledges, unstratified masses, and conglomerate deposits and boulders of rock material 3/4 cu. yd. (0.57 cu. m) or more in volume.

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- J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
 - K. Subbase Course: Layer placed between the subgrade and base course for asphalt paving, or layer placed between the subgrade and a concrete pavement or walk.
 - L. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
 - M. Undercutting: Necessary excavation of poor-quality soils which occur below the existing Topsoil and any uncontrolled fill soils as described in the Geotechnical Investigation.
 - N. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.
- 1.4 SUBMITTALS
- A. Product Data: For the following:
 - 1. Drainage fabric if required for the project.
 - 2. Separation fabric if required for the project.
 - B. Test Reports: Testing Agency shall submit the following reports directly to the Engineer and shall copy the contractor:
 - 1. Analysis of soil materials, whether procured on or off site, and including fill, backfill, and borrow materials.
 - 2. In-place density test reports.
 - 3. Moisture-density relationship test reports.
 - 4. Compressive strength or bearing test reports.
 - C. Material Test Reports: Interpreting test results for compliance of the following with requirements indicated:
 - 1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for fill and backfill.
- 1.5 QUALITY ASSURANCE
- A. Testing Agency Services
 - 1. The Owner will secure and pay for the services of a qualified, independent geotechnical engineer to classify existing soil materials, to recommend and to classify proposed borrow materials when necessary, to verify compliance of materials with specified requirements, and to perform required field and laboratory testing. Geotechnical engineer shall be acceptable to the Engineer and the owner and shall be licensed to practice in the state in which the project is located.
 - B. Pre-excavation Conference: Conduct conference at Project site.
- 1.6 PROJECT CONDITIONS

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- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Engineer or Owner and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Engineer and Owner not less than three (3) calendar days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Engineer's or Owner's written permission.
 - 3. Contact utility-locator service for area where Project is located before excavating.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials without additional cost to Owner when sufficient satisfactory soil materials are not available from excavations. Contractor is responsible for doing an independent earthwork calculation and including any import of appropriate fill material required to bring the site to the proposed grades.
- B. Satisfactory Soil Material (ASTM D 2487): Free of stones larger than 2 inches in any dimension, trash, debris, organic material, other objectionable material and classified as follows:
 - 1. GP (poorly graded gravel).
 - 2. GM (silty gravel).
 - 3. GC (clayey gravel).
 - 4. SW (well-graded sand).
 - 5. SP (poorly graded sand).
 - 6. SM (silty sand).
- C. Unsatisfactory Soil Material (ASTM D 2487):
 - 1. SC (clayey sand).
 - 2. CL (lean clay).
 - 3. ML (silt).
 - 4. OL (organic clay).
 - 5. OL (organic silt).
 - 6. CH (fat clay).
 - 7. MH (elastic silt).
 - 8. OH (organic clay).
 - 9. OH (organic silt).
 - 10. PR (peat).
- D. Backfill and Fill: Satisfactory soil materials.

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- E. Subbase: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; Generally, either an MDOT Class II sand or 21AA gravel will meet this requirement.
- F. Base: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; Generally, either a MDOT Class II sand or 21AA gravel will meet this requirement.
- G. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; Generally, either an MDOT Class II sand or 21AA gravel will meet this requirement.
 - 1. Clean granular fill meeting MDOT Class II grading requirements.
 - 2. On-site granular deposits within the excavation can be used as engineered fill if approved by the geotechnical engineer and if selective excavation procedures are employed to manage existing clay deposits.
 - 3. Import fill as required to make-up volumes necessary to raise the building site.
- H. Bedding: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; Generally, either an MDOT 3G, 5G, 6A, or 34R will meet this requirement. Bedding requirements of the agencies having jurisdiction over the utility installation take precedence over these specifications.
- I. Drainage Fill: Washed, narrowly graded mixture of crushed stone, or crushed or uncrushed gravel; ASTM D 448; Generally, either an MDOT 6A or 34R will meet this requirement. Refer to the plans for specific requirements.
- J. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 ACCESSORIES

- A. Drainage Fabric: Nonwoven geotextile, specifically manufactured as a drainage geotextile; made from polyolefins, polyesters, or polyamides; with minimum properties determined according to ASTM D 4759 and referenced standard test methods.
- B. Separation Fabric: Woven geotextile, specifically manufactured for use as a separation geotextile; made from polyolefins, polyesters, or polyamides; with minimum properties determined according to ASTM D 4759 and referenced standard test methods.

PART 3 EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.

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- C. Provide erosion-control measures approved by agency having jurisdiction to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.2 EXPLOSIVES

- A. Explosives: Explosives are prohibited for use on the Project site.

3.3 EXCAVATION; GENERAL

- A. General: Excavation includes the removal of any materials necessary to achieve the required subgrade elevations and includes reuse or disposal of such materials.
- B. Unnecessary Excavation: The expense of excavation of materials outside of limits indicated or ordered in writing by the Engineer and the correction thereof to the satisfaction of the Engineer shall be borne by the contractor.
 - 1. Unnecessary excavation under footings: Either deepen footings to bear on actual subgrade elevation without changing top elevations or place concrete fill up to required elevation, as required by the Engineer.
 - 2. Unnecessary excavation other than under footings: Either place compacted fill or otherwise correct conditions, as required by the Engineer.
- C. Approval of Subgrade: Notify the Testing Agency when required elevations have been reached.
 - 1. When required by the Engineer due to the unforeseen presence of unsatisfactory materials or other factors, perform additional excavation and replace with approved compacted fill material in accordance with the Engineer's or geotechnical engineer's instructions.
 - 2. Payment for unforeseen additional work will be made in accordance with established unit prices or, if none, in accordance with provisions for changes in the work. No payment will be made for correction of subgrades improperly protected against damage from freeze-thaw or accumulation of water, or for correction of otherwise defective subgrades.
- D. Excavation Stabilization: Slope faces of excavations to maintain stability in compliance with requirements of governing authorities. Do not use shoring and bracing where faces can be sloped.

3.4 EXCAVATION FOR STRUCTURES

- A. Do not proceed with excavations for building structures until Subgrade Preparation operations are complete and tested.
- B. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. Extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

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1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 2. Pile Foundations: Stop excavations from 6 to 12 inches (150 to 300 mm) above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
 3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended for bearing surface.
- C. Coordinate excavations with Dewatering operations as required to allow construction of foundations to dry.
- 3.5 EXCAVATION FOR WALKS AND PAVEMENTS
- A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.
- 3.6 EXCAVATION FOR UTILITY TRENCHES
- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated.
- C. Trench Bottoms: Excavate and shape trench bottoms in accordance with the plans and standard details. Excavate trenches a minimum 4 inches (100 mm) deeper than bottom of pipe elevation to allow for bedding course (excavate deeper as required by the regulating agency). Hand excavate for bell of pipe. Remove projecting stones and sharp objects along trench subgrade.
1. Excavate trenches a minimum 4 inches (100 mm) deeper than bottom of pipe elevation to allow for bedding course (excavate deeper as required by the regulating agency). Hand excavate for bell of pipe. Remove projecting stones and sharp objects along trench subgrade. Provide bedding course per the plan notes and/or details.
- 3.7 SUBGRADE PREPARATION AND INSPECTIONS
- A. Perform mass earthwork operations to remove all existing topsoil and other organic materials in their entirety within the footprint of the proposed building and pavement areas. Buried objects should be removed in their entirety.
- B. Notify Testing Agency when excavations have reached required subgrade elevations.

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- C. Proof-roll subgrade in the presence of the Testing Agency to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 - 1. Completely proof-roll subgrade in one direction repeating proof-rolling in direction perpendicular to the first direction. Limit vehicle speed to 3 mph.
 - 2. Proof-roll subgrade with heavy pneumatic-tired equipment or loaded 10-wheel, tandem-axle truck weighing not less than 15 tons.
 - 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Testing Agency, and replace with engineered fill as directed.
 - D. If Testing Agency determines that unsatisfactory soil is present, continue excavations and replace with compacted backfill or fill materials as directed.
 - 1. Additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
 - E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities.
- 3.8 UNAUTHORIZED EXCAVATION
- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill may be used at no additional cost to the Owner.
- 3.9 STORAGE OF SOIL MATERIALS
- A. Stockpile borrow materials and satisfactory excavated soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
- 3.10 BACKFILL
- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade includes, where applicable, damp proofing, waterproofing, and perimeter insulation.
 - 2. Surveying locations of underground utilities for record documents.
 - 3. Inspecting and testing underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing trash and debris.
 - 6. Removing temporary shoring and bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- 3.11 UTILITY TRENCH BACKFILL

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- A. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- B. Place and compact initial backfill of subbase material, free of particles larger than 1 inch, to a height of 12 inches over the utility pipe or conduit. All pipe backfill to be done according to the details shown on the plans or the requirements of the regulating agency.
- C. Fill voids with approved backfill materials while shoring and bracing, and as sheeting is removed.

3.12 FILL

- A. Preparation: Remove vegetation, topsoil, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface before placing fills.
- B. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- C. Place and compact fill material in layers to required elevations as follows:
 - 1. Under grass and planted areas, use satisfactory soil material.
 - 2. Under walks and pavements, use engineered fill.
 - 3. Under steps and ramps, use engineered fill.
 - 4. Under building slabs, use engineered fill.
 - 5. Behind walls, use engineered drainage fill.
 - 6. Under footings and foundations, use engineered fill.
 - 7. Over excavated areas, use engineered fill or lean concrete.

3.13 MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within two (2) percent of optimum moisture content.
 - 1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

3.14 COMPACTION OF BACKFILLS AND FILLS

- A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil to not less than the following percentages of maximum dry unit weight according to ASTM D 698 and ASTM D 1557:
 - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill material at 95 percent.

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2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material at 95 percent.
3. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill material at 88 percent.

3.15 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish Subgrades to required elevations within plus or minus 1 inch.
- C. Grading Inside Grading Lines: Finish subgrade to a tolerance of ½ inch, when tested with a 10 foot straight-edge.
- D. Contractor shall confirm that the proposed grades shown on the plans will not create a ponding water condition (i.e., an unintended low spot or pavement grades of less than 1%).

3.16 SUBSURFACE DRAINAGE

- A. Drainage Piping: Drainage pipe is specified in Division 33 Section 4100.
- B. Subsurface Drain: Place a layer of drainage fabric around perimeter of drainage trench. Place a 6-inch course of filter material on drainage fabric to support drainage pipe. Encase drainage in a minimum of 12 inches of filter material and wrap in a drainage fabric, overlapping sides and ends at least 6 inches.
 1. Compact each course of filter material to 95 percent of maximum dry unit weight according to ASTM D 698.
- C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade. Overlay drainage backfill with one layer of drainage fabric, overlapping sides and ends at least 6 inches.
 1. Compact each course of filter material to 95 percent of maximum dry density according to ASTM D 698.

3.17 SUBBASE AND BASE COURSES

- A. If indicated on the plans or deemed necessary by the geotechnical engineer, install separation fabric on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.

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- B. Under pavements and walks, place subbase course on separation fabric according to fabric manufacturer's written instructions if fabric is called for on the plan or deemed necessary by the geotechnical engineer.
- C. Under pavements and walks, place base on prepared subbase or subgrade as follows:
 - 1. Place base course material over subbase (or subgrade if subbase is not indicated).
 - 2. Compact subbase and base courses at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 98 percent of maximum dry unit weight according to ASTM D 1557.
 - 3. When thickness of compacted subbase or base course exceeds 6 inches, place materials in equal layers, with no layer more than 6 inches thick or less than 3 inches thick when compacted.
- D. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layers to not less than 98 percent of maximum dry unit weight according to ASTM D 1557.

3.18 DRAINAGE COURSE

- A. Under slabs-on-grade, if indicated on the plans, place drainage fabric on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
- B. Under slabs-on-grade, place drainage course on prepared subgrade and as follows:
 - 1. Compact drainage course to required cross sections and thickness to no less than 95 percent of maximum dry unit weight according to ASTM D 698.
 - 2. When compacted thickness of drainage course exceeds 6 inches, place materials in equal layers, with no more than 6 inches thick or less than 3 inches thick when compacted.

3.19 FIELD QUALITY CONTROL

- A. Testing Agency: Construction Manager/Owner will engage a qualified independent Geotechnical engineering testing agency to perform field quality-control testing.
- B. Allow testing agency to inspect and to test any subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work. Comply with requirements.
- C. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable.
- D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate and remove and replace soil to depth required, recompact and retest until specified compaction is obtained.

3.20 PROTECTION

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- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces becomes eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
- C. Protect all existing trees, bushes, plants, etc. indicated to remain during construction activities.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Unless otherwise indicated on the drawings or the Due Care Plan for Construction, remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.
 - 1. Do not burn materials on the Owner's property.

END OF SECTION

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SECTION 312319

DEWATERING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes but is not limited to construction dewatering.
- B. Related Sections include the following:
 - 1. Division 01 5000 Section "Temporary Facilities and Controls" for temporary utilities and support facilities.
 - 2. Division 31 2000 Section "Earth Moving" for Excavation Support and Protection."
 - 3. Division 31 2000 Section "Earth Moving" for excavating, backfilling, site grading and for site utilities.
 - 4. Division 33 4600 Section "Subdrainage" for permanent foundation wall, underfloor, and footing drainage.

1.3 PERFORMANCE REQUIREMENTS

- A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control ground-water flow into excavations and permit construction to proceed on dry, stable subgrades.
 - 1. Maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
 - 2. Prevent surface water from entering excavations by grading, dikes, or other means.
 - 3. Accomplish dewatering without damaging existing buildings adjacent to excavation.
 - 4. Remove dewatering system if no longer needed.
 - 5. Dewatering per Due Care Plan for Construction & Agency Permit.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with water disposal requirements of authorities having jurisdiction. Provide appropriate soil erosion and sedimentation control measures
- B. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 3100 Section "Project Management and Coordination."

1.5 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Owner/Architect and then only after arranging to provide temporary utility services according to requirements indicated.

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- B. Project-Site Information: Due Care Plan for Construction
- C. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner and Architect will not be responsible for interpretations or conclusions drawn from this data. If field conditions are encountered that are different from those expected based on the soil borings, notify all team members immediately.
 - 1. Make additional test borings and conduct other exploratory operations necessary for dewatering.
 - 2. The Due Care Plan for Construction is included or referenced elsewhere in the Project Manual.
 - 3. The geotechnical report is included or referenced elsewhere in the Project Manual.
- D. Survey adjacent structures and improvements, employing a qualified professional engineer or land surveyor, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
 - 1. During dewatering, regularly resurvey benchmarks maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
 - 1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
 - 2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
- B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

3.2 INSTALLATION

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- A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
 - B. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed, or until dewatering is no longer required.
 - C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
 - 1. Do not permit open sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
 - D. Avoid hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
 - 1. Maintain piezometric water level a minimum of 24 inches below surface of excavation.
 - E. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
 - 1. Agency permit required per Due Care Plan for Construction
 - F. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to Owner.
 - 1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.
 - G. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.
- 3.3 OBSERVATION WELLS
- A. Provide, take measurements, and maintain at least the minimum number of observation wells or piezometers indicated and additional observation wells as may be required by authorities having jurisdiction.
 - B. Observe and record daily elevation of ground water and piezometric water levels in observation wells.

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- C. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. Suspend construction activities in areas where observation wells are not functioning properly until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
 - 1. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

END OF SECTION

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SECTION 312400

GREEN STORMWATER INFRASTRUCTURE

PART 1 – GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall furnish all labor, materials, equipment, transportation, services, and necessary appurtenant work as required to complete the work as shown on the Plans and/or as specified herein.
- B. Work shall include but not be limited to:
 - 1. Excavation and backfilling
 - 2. Placing Impermeable Liners, Geotextiles, Aggregates, Stone, and Underdrains
 - 3. Placing bio-retention soil mix and fine grading
 - 4. Placing finished stonework for Green Stormwater Infrastructure

1.2 DEFINITIONS

- A. When the phrase “Stormwater Planting” is used in the specifications, it refers to plants installed in green stormwater infrastructure areas, such as stormwater planters, bio-retention, and raingardens.
- B. When the phrase “Bio-Retention Soil Mix” is used in the specifications, it refers to soil installed in green stormwater infrastructure areas, such as stormwater planters, bio-retention, and raingardens.
- C. When the phrase “impermeable liner” is used in the specifications, it refers to impermeable liner system that lines the perimeter and bottom of the green stormwater infrastructure area to prevent stormwater infiltration into existing soils below the impermeable liner.
- D. Definition of Landscape Maintenance and Guarantee Period: Refer to 329320 Landscape Maintenance and Guarantee.

1.3 RELATED DOCUMENTS

- A. Attention is directed to Bidding and Contracting requirements, drawings and general provisions of the Contract, including General Conditions, which are hereby made part of this section.
- B. Related Sections:
 - 1. Fine Grading, Lawn Seeding, and Site Stabilization 329200
 - 2. Planting 329310
 - 3. Landscape Maintenance and Guarantee 329390
 - 4. Earth Moving 312000

1.4 REFERENCE SPECIFICATION

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- A. AOSA -Association of Official Seed Analysis: Rules for testing Seeds, Journal of Seed Technology, 1991 Edition
- B. TAPPI-Technical Association of the Pulp and Paper Industry
- C. AOAC - Official Methods of Analysis, Association of Official Analytical Chemists.
- D. Materials and Work covered under this Section shall be in accordance with MDOT (2022 edition), Wayne County standards and specifications unless otherwise indicated. If a conflict exists between specifications, the more rigorous shall govern.
- E. ASTM-American Society for Testing and Materials
- F. AASHTO- American Association of Highway and Transportation Officials

1.5 QUALITY ASSURANCES

- A. Stone work shall be carried out by CONTRACTOR and their employees who are thoroughly experienced and skilled in the necessary crafts, and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this Section.
 - 1. Single Source Responsibility: Provide cobble and fieldstone from same source.

1.6 INFORMATIONAL SUBMITTALS

- A. Aggregates: CONTRACTOR to provide manufacturer's product data, including installation instructions, certifying that each material item complies with (or exceeds) specified requirements. The CONTRACTOR shall provide full scale samples OR photos with an object for scale of each stone type indicated, representative of all variations to be expected in the finished installation.
- B. Impermeable Liner and Geotextiles: Product Certificates and manufacturer's information.
- C. Topsoil and Compost: The CONTRACTOR shall submit to the CONSULTANT physical samples and results of the soils analysis dictated in TOPSOIL and COMPOST section of this specification.
- D. The CONTRACTOR shall provide the CONSULTANT with a construction sequencing plan that proposes a method to establish stormwater planting areas prior to the activation of the on-site storm water or provides some method of diversion of that storm water until such time as the stormwater planting can establish itself.

PART 2 – PRODUCTS

2.1 AGGREGATES and STONE

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- A. MDOT 6A: Coarse aggregate used in the construction of the underdrains of Green Stormwater Infrastructure systems and as a compacted bedding material for stonework shall be clean, double washed stone, conforming to MDOT gradation standards.
- B. Pea Gravel: Pea gravel used as the choker layer in the construction of the underdrains of Green Stormwater Infrastructure systems. The pea gravel used in the underdrains of Green Stormwater Infrastructure systems shall be clean, double washed stone, conforming to MDOT gradation standards.
- C. 2NS Sand used as the filter layer in the construction of the underdrains of Green Stormwater Infrastructure systems shall conform to the Aggregates section of the current MDOT Standard Specifications for Construction.
- D. Native Cobble: Native cobble for Cobble Swales, as shown on the plans and details, to be 4-10" native cobble, with a 6" average dimension.
 - 1. Cobble Swales to be comprised of 4-10" native cobble chocked with 1-2" stone.
- E. Native Fieldstone: Native fieldstone for Cobble Drain Outlet, Concrete Curb Inlet, and Trench Drain Headwall, as shown on the plans and details, to be 12-18" native fieldstone, from same source as native cobble.

2.2 NON-WOVEN GEOTEXTILE SEPARATOR

- A. Geotextile separator for stonework shall be 4-1/2oz. needlepunch polypropylene non-woven as supplied by Price and Company (1.866.960.4300), or approved substitution.

2.3 TOPSOIL

- B. Topsoil for Bio-Retention Soil Mix shall be friable sandy loam capable of supporting optimal plant growth and development. It shall be free of clay lumps, subsoil, invasive weeds and seeds, stones, sticks and other extraneous materials.
- C. Quantity: The CONTRACTOR shall be responsible for estimating the quantity imported topsoil necessary to obtain the specified depth of topsoil to be re-spread. The CONTRACTOR shall report any discrepancy between work on the Plans and in the Specifications to the CONSULTANT.
- D. Analysis for existing and any necessary imported topsoil for Stormwater Planting areas shall be done at the CONTRACTOR'S expense and shall be submitted to OWNER/CONSULTANT for approval prior to use.
- C. The structural topsoil analysis for Stormwater Planting areas shall be within the listed parameters:
 - 1. Clay content: 10 -20%
 - 2. pH range: 6.5 – 8.0
 - 3. Organic matter content: 3-10%: Compost may be added as an amendment to satisfy organic matter content percentages.
 - 4. Soil Textural Analysis: defines the percentages of sand, silt, and clay and classifies topsoil as a sandy loam.
 - 5. Testing for topsoil for Stormwater Planting areas may be performed through A&L Great Lakes Laboratories, Inc., Fort Wayne Indiana 260.483.4759.

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- D. Sample: 1-gallon sample of topsoil that represents topsoil to be used on actual project in a sealed plastic bag.

2.3 COMPOST

- A. Compost shall be used only from a facility registered within the State of Michigan, or as approved by CONSULTANT. At least fourteen (14) working days in advance of construction and before delivery of compost, Contractor must submit the following to the Engineer for approval:
 - B. Sample: 1-gallon sample of compost that represents compost to be used on actual project in a sealed plastic bag.
 - C. Technical data sheet showing the following:
 - 1. A statement that the compost meets federal and state health and safety regulations.
 - 2. A compost technical data sheet from the vendor of the compost. The analysis and report must be consistent with the sampling and reporting requirements of the US Composting Council Seal of Testing Assurance (STA) program. The date of analysis shall be no more than ninety (90) calendar days prior to the date of submittal.
- D. Quantity: The CONTRACTOR shall be responsible for estimating the quantity of compost necessary to obtain the necessary organic content of the topsoil should the testing for organic matter be below the specified amount. The CONTRACTOR shall report any discrepancy between work on the Plans and in the Specifications to the CONSULTANT.

2.4 BIO-RETENTION SOIL MIX

- A. Bio-Retention Soil mix shall consist of a mixture containing the soil components and amendments listed below. The bio-retention soil mix shall be thoroughly mixed off site at a clean location. The material shall be well mixed, homogenous, loose friable, have no visible free water, and be free of wood pieces, plastic and other foreign matter. The soil mixture shall be protected from all sources of contamination, including weed seeds, while at the supplier, in conveyance and at the project site.
- B. Bio-Retention Soil mix to be comprised of three (3) parts Imported Topsoil and one (1) part Compost.

2.5 EROSION CONTROL BLANKET

- A. Erosion control blanket shall be North American Green Straw Erosion Control Blanket S150 BN, 100% biodegradable, jute netted, or approved substitution.
- B. Pegs shall be of sound wood and sized per MDOT Standard Specifications, latest edition.
- C. Erosion control blanket supplier: Erosion control blanket is available through Price and Company, Inc., Wyoming, MI (P) 616.530.8230.

2.5 IMPERMEABLE LINER

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- A. Impermeable liner shall be a geomembrane a minimum of 30 mils thick and ultraviolet resistant (ASTM D7176).

2.7 UNDERDRAINS

- A. 6" Perforated PVC Pipe as indicated on the Contract Drawings. No sock.

PART 3 - EXECUTION

3.1 OBSERVATION OF THE WORK

- A. The CONSULTANT shall be informed of the progress of the work so that the work may be observed at key critical stages of construction including completion of excavation and subgrade work; completion of installation of impermeable liner and underdrain; and installation of Bio-Retention soil. The CONSULTANT shall be afforded a minimum of three (3) working days' notice to schedule visits to the site. Failure of the CONSULTANT to make field observations shall not relieve the Contractor from meeting all the requirements of this specification.

3.2 SOIL COMPACTION

- A. It is very important to minimize compaction of both the base of the green stormwater infrastructure area and of the side-slopes of the excavation. Operate equipment adjacent to, and not within the footprint of the green stormwater infrastructure areas whenever possible. Equipment operation within the facility should be avoided to prevent soil compaction. If machinery must operate in the facility, use lightweight, low ground contact pressure equipment (no more than 4 psi) and ensure that existing ground infiltration rate has not been reduced as a result.
- B. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high pressure tires will cause excessive compaction resulting in reduced infiltration rates and is not acceptable. Improper compaction will significantly contribute to design failure.
- C. Compaction can be alleviated at the base of the green stormwater infrastructure areas by using a primary tilling operation such as a chisel plow, ripper, or subsoiler. These tilling operations are to refracture the soil profile through the 24-inch compaction zone. Substitute methods must be approved by the CONSULTANT. Rototillers typically do not till deep enough to reduce the effects of heavy equipment.
- D. No storage of equipment, materials, debris, or any other items shall be allowed in the areas designated as bio-retention areas on the Drawings for any length of time.
- E. Excavation or placement of material will not be allowed if any portion of the bioretention area is wet or saturated or has been subjected to more than ½ inch of precipitation within 48 hours prior to the proposed construction activities. The CONSULTANT shall have final authority to determine if wet or saturated conditions exist.

3.3 EXCAVATION

- A. Excavation, subgrade, and backfill shall conform to the – EARTH MOVING Section (312000) – of these Specifications (unless otherwise noted).
- B. Excavate the bottom of the green stormwater infrastructure areas to the depth shown on the Drawings. Do not use heavy equipment within any area designated as a green stormwater

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infrastructure area shown on the Drawings.

- C. CONTRACTOR shall slope site grades to direct surface runoff away at end of each day to avoid water damage to the swale, drain outlet, or stone at culvert end while under construction.
- D. Any surface drainage features, finish grading, erosion control, or turf shall be installed immediately after cobble swales, drain outlets are completed.
- E. If site and soil conditions, Cobble Swales, Cobble Drain Outlets, or loadings are different than in the Drawings and the design parameters, the CONTRACTOR must contact CONSULTANT prior to proceeding with the construction.

3.4 INSTALLATION OF IMPERMEABLE LINER

- A. The impermeable liner shall be installed at the bottom of the bio-retention areas and along the side slopes to the ponding elevation, to prevent stormwater infiltration into existing soils below the geomembrane.
- B. Seal the seams of the impermeable liner per manufacturer's instructions and follow ASTM D7408 Standards. Seams shall be appropriately sealed so as not to allow migration of water to the existing subgrade and site soils below the impermeable liner.

3.5 PROTECTION

- A. Runoff Control: Construction site runoff from disturbed areas shall not be allowed to enter the green stormwater infrastructure areas during construction. Contractor shall use sediment control measures and flow diversions as necessary to prevent construction site runoff from entering the bio-retention basins during any of the construction phases until the bio-retention system is finalized and stabilized.
- B. Contractor shall not construct Green Stormwater Infrastructure areas until all contributing drainage areas are stabilized to the satisfaction of the CONSULTANT. Do not use the Green Stormwater Infrastructure areas as temporary sediment control facilities during construction. Any sediment that enters the Green Stormwater Infrastructure areas during construction shall be removed by the Contractor at no cost to the Owner. The bio-retention soil mix and double washed aggregate used within the Green Stormwater Infrastructure system shall remain free of sediment.

3.6 BACKFILLING

- A. Bioretention Soil Mix: Place Bioretention Soil in 6" lifts over all areas designated as Green Stormwater Infrastructure areas. Compact soil to a maximum of 75- 85% Proctor density according to ASTM D698. Compaction can be obtained by lightly tamping with bucket as necessary.
- B. Soil media will be considered defective if it does not pass tests and inspections and should be replaced or restored as directed by CONSULTANT. Place soil with equipment located outside the bio-retention excavation. No equipment shall be allowed to drive across installed locations. Any soil observed being driven on may be subject to removal and reinstallation at Contractor's own expense. Contractor shall gain approval from CONSULTANT of installation method prior to beginning installation. Contractor shall provide three (3) working days' notice to CONSULTANT prior to beginning installation.

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- C. Final Grading: Grade bio-retention soil media to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades. Stabilize in accordance with applicable local regulatory requirements. Avoid erosion of green stormwater infrastructure areas from overwatering, foot traffic, or machine compaction. Repair any damaged areas and areas that have the potential to cause erosion or have caused erosion at no cost to the Owner.

3.7 COBBLE SWALES, INLETS, AND COBBLE DRAIN OUTLETS

- A. Install stone and cobble at all pipe or surface inlet locations as indicated on the drawings.
- B. Install stone and cobble in a manner that materials are interlocking as much as possible to minimize movement with concentrated water flows.

3.8 EROSION CONTROL BLANKET

- A. Install Erosion control Blanket on all regraded side slopes surrounding all green stormwater infrastructure areas. Install immediately after finish grading is completed. Install per manufacturer's instructions.
- B. If erosion control blanket is indicated or needed in areas where plants are present, install erosion control blanket prior to planting.
- C. If erosion control blanket is indicated or needed in seeding areas, install erosion control blanket after seeding.

3.9 TESTING AND ACCEPTANCE

- A. When construction is complete, the Contractor shall test all completed underdrain systems for continuous, unimpeded flow.
 - 1. Suggested test methods for each pipe run are as follows:
 - a. At highpoint or upstream end of underdrain pipe, open cleanout and insert hose from water source.
 - b. Turn on water.
 - c. Acceptance of pipe run consists of free flow of water through the drain outlet into the storm system.
 - 2. Any sections of underdrain that are clogged or crushed shall be replaced or repaired at the Contractor's expense.
 - 3. Installed work shall be reviewed and approved by the Engineer/CONSULTANT for acceptance.

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- B. Any movement (i.e. upheaval or settlement) of stonework within a one-year period after final acceptance shall be brought to proper grade and intended configuration for the detail by the CONTRACTOR at no expense to the OWNER.
- C. Any non-secure or disturbed stone shall be repaired or replaced as determined by the CONSULTANT at no expense to the OWNER.

END OF SECTION

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SECTION 313116

TERMITE CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. Work required for this Section includes soil treatment for termite control including supplementary Work necessary for its installation.

1.2 DEFINITIONS

- A. EPA: Environmental Protection Agency.
- B. PCO: Pest control operator.

1.3 ACTION SUBMITTALS

- A. Product Data: Treatments and application instructions, including EPA-Registered Label.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: Signed by manufacturers of termite control products certifying that treatments furnished comply with requirements.
- B. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's record information, including the following as applicable:
 - 1. Date and time of application.
 - 2. Moisture content of soil before application.
 - 3. Brand name and manufacturer of termiticide.
 - 4. Quantity of undiluted termiticide used.
 - 5. Dilutions, methods, volumes, and rates of application used.
 - 6. Areas of application.
 - 7. Water source for application.
- C. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Applicator Qualifications: A PCO who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment in jurisdiction where Project is located and who is experienced and has completed termite control treatment similar to that indicated for this Project and whose work has a record of successful in-service performance.
- B. Regulatory Requirements: Formulate and apply termiticides, and label with a Federal registration number, to comply with EPA regulations and authorities having jurisdiction.

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1.6 PROJECT CONDITIONS

- A. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with EPA-Registered Label requirements and requirements of authorities having jurisdiction.

1.7 COORDINATION

- A. Coordinate soil treatment application with excavating, filling, and grading and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs, before construction.

1.8 WARRANTY

- A. Special Warranty: Written warranty, signed by applicator and Contractor certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.
- B. Warranty Period: Five years from date of Substantial Completion.

1.9 MAINTENANCE SERVICE

- A. Continuing Service: Provide a proposal for continuing service, including monitoring, inspection, and retreatment for occurrences of termite activity, from applicator to Owner, in the form of a standard yearly (or other period) continuing service agreement, starting on the date of Substantial Completion. State services, obligations, conditions, and terms for agreement period and for future renewal options.

PART 2 - PRODUCTS

2.1 SOIL TREATMENT

- A. Termiticide: Provide an EPA-registered termiticide complying with requirements of authorities having jurisdiction, in a soluble or emulsible, concentrated formulation that dilutes with water or foaming agent, and formulated to prevent termite infestation. Use only soil treatment solutions that are not harmful to plants. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to the product's EPA-Registered Label.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of the soil, interfaces with earth moving, slab and foundation work, landscaping, and other conditions affecting performance of termite control.

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- B. Proceed with application only after unsatisfactory conditions have been corrected. Starting of Work will be construed as installers acceptance of installation conditions.

3.2 PREPARATION

- A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparing substrate. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated, except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended by termiticide manufacturer.
- C. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

3.3 APPLYING SOIL TREATMENT

- A. General: Apply soil treatment under all enclosed structures. Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's EPA-Registered Label for products.
- B. Application: Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute the treatment evenly.
- C. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
- D. Foundations: Adjacent soil including soil along entire inside perimeter of foundation walls, along both sides of interior partition walls, around plumbing pipes and electric conduit penetrating slab, and around interior column footers, piers, and chimney bases; and along entire outside perimeter, from grade to bottom of footing. Avoid soil washout around footings.
- E. Crawlspace: Soil under and adjacent to foundations as previously indicated.
- F. Adjacent Areas: Around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
- G. Penetrations: At expansion joints, control joints, and area where slabs will be penetrated.
- H. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- I. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.

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- J. Post warning signs in areas of application.
- K. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

END OF SECTION

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SECTION 316329

DRILLED CONCRETE PIERS AND SHAFTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Provide drilled concrete piers in accordance with the requirements of the Contract Documents.
- B. Drilled excavation.
- C. Temporary casing.
- D. Concrete materials and mix.
- E. Reinforcement.

1.2 RELATED REQUIREMENTS

1.3 REFERENCE STANDARDS

- A. ACI 301, "Specifications for Structural Concrete".
- B. ACI 318-11, "Building Code Requirements for Structural Concrete".
- C. ACI 315 SP-66, "ACI Detailing Manual".
- D. ACI SPEC-336.1 - Construction of Drilled Piers - Specification; 2024.
- E. Other ACI standards as applicable.
- F. American Welding Society (AWS) D1.1/D1.1M:2010, "Structural Welding Code - Steel".
- G. American Welding Society (AWS) D1.4/D1.4M:2011, "Structural Welding Code – Reinforcing Steel".
- H. 2021 Michigan Building Code with local jurisdiction amendments.
- I. Drilled Shaft Inspector's Manual (2nd edition) (#TM-DS-1)

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.

1.5 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Submit a Method Statement covering a comprehensive description of the proposed equipment, drilling method, temporary casing and construction procedures for drilled piers. The Method Statement shall also include procedures for confirming homogeneity of piers. The Method Statement shall be reviewed by the Owner's Testing Agency and Geotechnical Engineer.
- C. Shop Drawings: Indicate details and schedules of pile installation sequence.
- D. Submit mix designs for each concrete mixture stating where each mix will be used, the mix proportions, materials and admixtures and their proportions, and any additional design information

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as required. Mix designs shall be prepared and stamped by a Civil Engineer licensed in the State of Michigan. Contractor shall provide and pay for mix designs. Submit mix designs on the Mix Design Submittal Form included at the end of this specification. Alternate similar forms are acceptable.

- E. Furnish certified test results, including mill certificates, for material and mixes showing that the mix proportions and materials comply with the specified characteristics.
- F. Furnish certified mill reports covering the chemical and physical properties of the reinforcing bars and other steel products used.
- G. Installer's qualification statement.
- H. Submit reports for the specified Source Quality Control and Field Quality Control inspections and tests.
- I. Project Record Documents: Record actual locations of piers, pier diameter, and pier length. Accurately record the following:
 - 1. Sizes, lengths, and locations of piers.
 - 2. Sequence of placement.
 - 3. Final base and top elevations.
 - 4. Deviation from indicated locations.
 - 5. Placement and configuration of reinforcement deviations.

1.6 QUALITY ASSURANCE

- A. Contractor's Quality Assurance: Contractor is solely responsible for quality control of the Work. Comply with the requirements specified in Section 01 4000, Quality Requirements.
- B. Regulatory Requirements: Comply with applicable requirements of the codes, and local ordinances. Obtain necessary approvals from all such authorities.
- C. Installer Qualifications: Company specializing in performing the work of this section with minimum 10 years of documented experience.

1.7 PROJECT / SITE CONDITIONS

- A. Subsurface Soil Investigation Report: Owner will make available the Geotechnical Investigation report, including supplements, prepared for the purposes of design, and indicating the general characteristics of the underlying soil conditions at the site. The report represents all conditions known to the Owner's Geotechnical Engineer but is not guaranteed to represent all conditions that may be encountered. Contractor shall notify the Architect if the report appears to be at variance with the actual conditions encountered.
- B. Site Survey: Owner will make available a survey of the site, existing utilities, and existing construction. The survey represents all conditions known to the Owner. Other construction, of which no records are available, may be encountered. Contractor shall formulate his/her own

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conclusions as to the extent of such construction and shall notify the Architect if the survey appears to be at variance with the actual conditions encountered.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Portland Cement: ASTM C 150, Type II, unless noted otherwise.
- B. Fly Ash: ASTM C618, Class F.
- C. Normal Weight Aggregates: ASTM C33, Class 2N coarse aggregate or better, graded. Furnish aggregates from same source for the entire Work.
 - 1. Coarse Aggregates: 1.5 inches nominal maximum size.
 - 2. Fine Aggregates: Uniformly graded, clean sand, free from excessive fines, organic materials, or other deleterious materials. Free of materials with deleterious reactivity to alkali in cement.
 - 3. Dry weight of normal weight concrete shall be as indicated on Drawings.
- D. Water Reducing, Plasticizing Admixture: ASTM C494, Type A.
- E. Water: ASTM C94, clean and free from deleterious matter.
- F. Steel Reinforcement Bars: ASTM A615, Grade 60 or ASTM A706, Grade 60 deformed bars.
- G. Mechanical Bar Couplers: Provide coupler capable of achieving Type 2 mechanical splice, unless otherwise noted on Drawings.
- H. Temporary Steel Casing: As required by site conditions and designed by Contractor.
- I. Miscellaneous Materials or Accessories: Provide as indicated and/or as required to complete the Work.

2.2 CONCRETE MIXTURES

- A. General: Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
 - 1. Procurement of concrete mix designs is the responsibility of Contractor.
 - 2. Use a qualified independent testing agency for preparing and reporting proposed mixture designs based on laboratory trial mixtures.
 - 3. Minimum Compressive Strength (f'_c): As indicated on Drawings. Concrete strength (f'_c) is the minimum compressive strength at 28 days, tested in accordance with ASTM C39.
 - 4. Use admixtures according to manufacturer's written instructions.
 - 5. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M, and furnish batch ticket information. Provide proper mix when concrete is placed by Tremie Method.
 - 6. Improper Mix: Notify the Architect and Testing Agency if, at any time during construction, the concrete resulting from the accepted mix design proves to be unsatisfactory for any reason. Modify the mix design until a satisfactory concrete is obtained, subject to the Architect's review.

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PART 3 EXECUTION

3.1 EXAMINATION

- A. Verification of Conditions: Examine the areas to receive the Work and the conditions under which the Work will be performed. The Contractor shall remedy conditions detrimental to the proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PROTECTION OF EXISTING UTILITIES

- A. Drilled Piers Adjacent to Existing Utilities: If any existing utilities and/or utility structures are known, notify the utility owner and the Architect before commencing Work and ensure that protective work is coordinated and performed in accordance with their requirements.
- B. Uncharted or Incorrectly Charted Utilities: If any unknown utilities and/or utility structures are encountered during pier drilling operations, notify the Architect and utility owner. Cooperate with the utility owner in keeping their respective services, utilities, and facilities in operation. Repair damaged utilities to the satisfaction of the utility owner.

3.3 PREPARATION

- A. Use placement method which will not cause damage to nearby structures.
- B. Prepare to place piers from existing site elevations.
- C. Grade perimeter of pier and shaft area to prevent surface water from draining into soil borings. Provide temporary means and methods, as required, to maintain surface diversion until no longer needed, or as directed by the Architect.

3.4 CONSTRUCTION OF DRILLED PIERS

- A. Comply with the requirements of the Geotechnical Investigation report and its supplements.
- B. Follow procedures stated in the accepted Method Statement.
- C. Construct piers in accordance with ACI SPEC-336.1.
- D. Drill vertical pier shafts, belled bases, shear rings, and rock sockets to minimum diameters and depths indicated, including removal of all known obstructions as necessary.
 - 1. Notify the Architect if obstructions not previously known are encountered and interfere with new construction.
- E. Where piers are located within 2 bell diameters (center-to-center) of adjacent piers, do not excavate adjacent piers until minimum 24 hours after concrete placement.
- F. Provide pumping and drainage for dewatering of pier shafts if required. Remove loose materials and free water from the bottom of pier shafts. Do not excavate below the elevations noted on Drawings.
- G. Provide additional excavation only when directed by the Geotechnical Engineer and/or after it is determined by testing that the material encountered at the elevations shown on Drawings is unsuitable or cannot support the design loads.

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- H. Clean shaft and bottom of loose material. Provide temporary means and methods, as required, to remove all water from soil borings as needed, or until directed by the Geotechnical Engineer.
- I. Dispose of excavated materials off site and in a manner that will not interfere with other construction activities. Keep the area clean at all times and free of spoil or other debris that could affect progress of Work.
- J. Provide casing or other approved means if caving occurs during drilling. Install casing by a suitable method and/or as directed by the Geotechnical Engineer.
 - 1. The casing system shall be designed by Contractor and be of sufficient strength to withstand handling stresses and pressures from concrete, soil, hydrostatic or other conditions encountered during construction, in order to prevent caving of soil.
 - 2. Withdraw the casing as directed by the Geotechnical Engineer.
 - a. Keep the casing plumb and pull from the hole in a smooth vertical motion. Vibratory methods are prohibited.
 - b. Where the cutoff elevation is below ground level, maintain a protective liner up to the ground surface as necessary to prevent caving or intrusion of soils into the shaft.
 - c. Place and position dowels after casing has been pulled and the top surface of concrete has been established.
 - 3. When required by the Geotechnical Engineer, a casing may also be required where the pier is inside the zone of influence of existing shallow foundations. In such cases do not allow the excavation to be supported by freshly placed concrete. Remove casing as directed/permitted by the Geotechnical Engineer.
- K. Approval from the Geotechnical Engineer is required if the casing will be left in place. In such cases the Geotechnical Engineer may require additional corrective measures.
- L. If water conditions make excavation dangerous through soil strata, or excessive soil inflow creates voids outside the pier, notify the Geotechnical Engineer.
- M. Allow inspection of shaft and liner prior to placement of reinforcement and concrete.

3.5 PLACING OF CONCRETE

- A. Follow procedures stated in the accepted Method Statement.
- B. Do not place concrete in a pier if water inflow is detrimental to concrete strength or will endanger the excavation. Make every effort to seal off the water flow during excavation. Remove standing water, loose soil and debris from the bottom of piers before concrete placement.
- C. Start placing of concrete only after the excavation and reinforcing cage for the drilled pier have been completed and inspected and after the pier bottom has been cleaned, inspected and determined to be suitable for supporting the required bearing capacity by the Geotechnical Engineer. Holes shall be dry at the time of inspection. Do not remove hoses used for pumping out water until after starting concrete placement.
- D. Place concrete not later than 90 minutes after water was introduced in the mix. Provide suitable equipment for conveying of concrete. Continuously deposit concrete until completion of the pier to

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top of shaft. Do not suspend pouring of concrete in a pier more than 30 minutes. Remove laitance and excess water from the top of the completed pier.

- E. If site conditions require placing of concrete underwater by the tremie method, furnish description of proposed method for review by the Owner's Testing Agency and Geotechnical Engineer.
- F. Mark location of construction joints on the field record drawings whether joint is formed because concrete placement is suspended before pier completion or for any other reason. Roughen the joint and clean laitance and loose material from the joint before placing additional concrete.
- G. Extend reinforcement for connection of caps.
- H. Set tops of piers to elevations indicated.

3.6 TOLERANCES

- A. Install piers with maximum variation from location, plumbness, bottom area, diameter, and anchorage locations as specified in ACI SPEC-336.1.

3.7 FIELD QUALITY CONTROL

- A. Field inspection and testing will be performed under provisions of Section 014000 - Quality Requirements.
- B. Survey each pier shaft for location, plumbness and the final bottom and top elevations of the completed drilled pier.
- C. If specified tolerances are exceeded and/or installed Work is defective and does not meet Contract Documents, submit a description of proposed corrective construction for review. Architect may require additional testing and/or corrective measures at his/her discretion. Contractor is responsible for costs of all corrective work and associated testing.

3.8 OWNER'S MONITORING ACTIVITIES

- A. Owner's Testing Agency
 - 1. A testing agency, engaged by the Owner, will perform the following activities to monitor the Contractor's Quality Control Program. The monitoring activities in no way relieve the Contractor of sole responsibility for maintaining the Quality Control Program.
 - 2. Testing and Inspection shall conform to the requirements of the Michigan Building Code.
- B. General Activities
 - 1. Review Contractor's Method Statement and description of the proposed construction equipment, procedures, sequences, and details.
 - 2. Perform full-time visual inspection of each drilled pier installation.
 - 3. Inspect bottom of each drilled pier and test bearing surfaces, as required by the Geotechnical Engineer, to confirm if suitable for supporting the design loads and determine whether additional excavation is required. Drilled pier construction and inspection shall be in accordance with the Deep Foundation Institute Drilled Shaft Inspector's Manual (2nd Edition).
 - 4. Observe, record and report Contractor's tolerance measurements for location, plumbness, and final elevations of bottom and top of the completed pier.
- C. Pier Excavation

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1. Review Contractor's description of the corrective construction proposed where specified tolerances are exceeded.
2. Examine pier bottom.
3. Review Contractor's description of soil stabilization method proposed to correct conditions where water or soil inflow is encountered.
4. Visually inspect fabrication of casing. If any welding is done, verify AWS welder certifications and perform testing of welds in accordance with AWS D1.1 requirements.

D. Placing of Concrete

1. Inspect excavation, reinforcing, and shaft bottom to determine whether suitable for placement of concrete.
2. Inspect batch plant as required to ensure that concrete delivered to jobsite complies with the specifications and the design mix. Perform batch plant inspection once at start of job and thereafter if concrete falls below specification strength.
3. Perform continuous visual inspection of on-site reinforcing fabrication and installation, and all concrete placement, including verification of laitance removal at top of piers.
4. Review Contractor's proposed construction procedure for placing concrete by the tremie method if conditions warrant placing of concrete underwater.
5. Inspection of concrete placement by tremie method.
6. Concrete Sampling and Compressive Strength Tests: ASTM C31 and ASTM C39.
7. Sampling: Prepare standard 4" x 8" cylinders. Make 1 set of 5 cylinders for each 50 cu yd of concrete, or fraction thereof, but not less than 1 set of cylinders for each drilled pier. Make only 1 set from any one batch of concrete and all 5 cylinders from the same batch. In addition, make 1 cylinder from each truckload.
 - a. Curing: For each 5 cylinder set, cure 3 cylinders for 28 days at the job site to simulate the same curing conditions as concrete in the piers. Cure all other cylinders in the laboratory.
 - b. Testing: For each 5 cylinder set, test 1 cylinder at the age of 7 days, test 2 cylinders at the age of 28 days, and test the remaining cylinder at the age of 56 days if 28 day test result does not meet requirements. Test the cylinder from each truckload at the age of 7 days.
 - c. Test Report: State the location of the concrete pour in the pier, whether laboratory or site cure, age at testing, compressive strength, type of fracture, concrete supplier, mix specification strength and other pertinent information, and state whether concrete complies with the specifications.
8. Concrete Slump Tests: Per ASTM C143 at point of delivery. Make not less than 1 slump test for each truck.

E. Observe tests conducted by Contractor to confirm homogeneity of piers.

F. Perform additional testing if, in the opinion of the Inspector and Architect, Work performed by Contractor does not meet Contract Documents. Additional testing and all corrective work will be paid for by Contractor.

3.9 UNACCEPTABLE PIERS

- A. Unacceptable Piers: Piers that fail, are placed out of position, are below elevations, or are damaged.
- B. Provide additional piers or replace piers failing to comply with specified requirements.

END OF SECTION

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SECTION 32 1216

HOT-MIX ASPHALT CONCRETE PAVING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All paving materials and construction methods shall conform to the current standards and specifications of the Michigan Department of Transportation. Where these specifications are less stringent than the requirements of MDOT, the MDOT standards shall govern.

1.2 SUMMARY

- A. This Section includes installation of the following: Adjust list below to suit project.
 - 1. Hot-mix asphalt concrete paving.
 - 2. Hot-mix asphalt patching.
- B. Related Sections include the following:
 - 1. Division 31 1415 Section "Pavement Markings."
 - 2. Division 31 2000 Section "Earth Moving" for aggregate sub-base and base courses.

1.3 DEFINITIONS

- A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.
- B. MDOT: Michigan Department of Transportation.

1.4 REQUIREMENTS

- A. Provide hot-mix asphalt paving according to materials, workmanship, and other applicable requirements of MDOT'S most current Standard Specifications for Construction. Where notes in this specification section differ from the MDOT standards, the MDOT standards shall govern.
- B. Do not place asphalt when ambient air or base surface temperature is less than 40 degrees F (4 degrees C), or surface is wet or frozen.
- C. Place bitumen mixture when temperature is not more than 15 F degrees (8 C degrees) below bitumen supplier's bill of lading and not more than maximum specified temperature.

1.5 SUBMITTALS

- A. Submit aggregate and bituminous mix designs for review. Contractor shall confirm that the materials provided meet the required specifications and provide material certification to the engineer. Material certification shall state that the products meet or exceed the requirements indicated on the plans and the requirements of the regulating authority.

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1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer.
 - 1. Manufacturer shall be a paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of the state in which Project is located.
- B. Testing Agency Qualification Qualified according to ASTM D 3666 for testing indicated, as documented according to ASTM E 548.
- C. Regulatory Requirements: Comply with (MDOT) Michigan Department of Transportation's current Standard Specification for Construction for asphalt paving work.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp or if the following conditions are not met:
 - 1. Prime and Tack Coats: Minimum surface temperature of 60 deg F.
 - 2. Slurry Coat: Comply with weather limitations of ASTM D 3910.
 - 3. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 4. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.
- B. Pavement-Marking Paint: Apply pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil-based materials, 50 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Asphalt Cement: ASTM D 946.
- B. Aggregate for Base Course: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- C. Aggregate for Leveling Course: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- D. Aggregate for Wearing Course: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- E. Fine Aggregate: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- F. Mineral Filler: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- G. Tack Coat: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.

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2.2 ASPHALT MATERIALS

- A. Asphalt Binder: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- B. Asphalt Cement: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- C. Prime Coat: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- D. Prime Coat: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.
- E. Tack Coat: Conform with requirements of agency having jurisdiction. If paving is not subject to local review, conform with DOT standards.

2.3 AUXILIARY MATERIALS

- A. Paving Geotextile: AASHTO M 288, nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.
- B. Joint Sealant: ASTM D 3405 or AASHTO M 301, hot-applied, single-component, polymer-modified bituminous sealant.
- C. Pavement-Marking Paint: Refer to section 32 1415 "Pavement Marking".
 - 1. Color: As indicated on Drawings or in accordance with MDOT.
- D. Wheel Stops (if indicated): Precast, air-entrained concrete, 2500-psi minimum compressive strength, 6 inches high by 9 inches wide by 84 inches long. Provide chamfered corners and drainage slots on underside and holes for anchoring to substrate.
 - 1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

2.4 ASPHALT MIX DESIGN

- A. Hot-Mix Asphalt: Asphalt mixes shall conform with DOT standards. Mixes are noted on the plans.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that compacted subgrade is dry and in suitable condition to support paving and imposed loads.
- B. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction. Proof-roll as indicated in "Earth Moving" section 31 2000.
- C. Verify that gradients and elevation of base are correct.

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3.2 PATCHING

- A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.
- B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseal concrete pieces firmly.
 - 1. Pump hot undersealing asphalt under rocking slabs until slab is stabilized or, if necessary, crack slab into pieces and roll to reseal pieces firmly.
 - 2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.
- C. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd.
- D. Patching: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.3 REPAIRS

- A. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than 1 inch in existing pavements.
 - 1. Install leveling wedges in compacted lifts not exceeding 3 inches thick.
- B. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of 1/4 inch minimum or as indicated.
 - 1. Use hot-applied joint sealant to seal cracks and joints more than 1/4 inch wide. Fill flush with surface of existing pavement and remove excess.

3.4 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared compacted subgrade is ready to receive paving.
- B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
- C. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd. Apply enough material to penetrate and seal but not flood surface. Allow prime coat to cure for 72 hours minimum.

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- D. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd.

3.5 HOT-MIX ASPHALT CONCRETE PLACING

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
 - 1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
 - 2. Place hot-mix asphalt surface course in single lift.
 - 3. Spread mix at minimum temperature of 250 deg F.
 - 4. Install work in accordance with Michigan Department of Transportation (MDOT).
 - 5. Compact pavement by rolling to density specified. Re-roll as necessary to achieve even and smooth finish without roller marks.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
- C. Promptly correct surface irregularities in paving course behind paver. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions with same texture and smoothness as other sections of hot-mix asphalt course.
 - 1. Clean contact surfaces and apply tack coat to joints.
 - 2. Construct transverse joints as described in AI MS-22, "Construction of Hot Mix Asphalt Pavements."

3.7 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.
 - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness.
 - 1. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 2. Average Density: 96 percent of reference laboratory density according to AASHTO T 245, but not less than 94 percent nor greater than 100 percent.

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- C. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 INSTALLATION TOLERANCES

- A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 - 1. Base Course: Plus, or minus 1/2 inch.
 - 2. Surface Course: Plus 1/4 inch, no minus.
- B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course: 1 1/2 inch
 - 2. Surface Course: 2 1/2 inch
 - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown.
Maximum allowable variance from template is 1/4 inch.
- C. Confirm minimum 1% slopes on asphalt pavement surfaces. Notify engineer prior to asphalt placement if minimum 1% slope is not met in any areas.

3.9 PAVEMENT MARKING

- A. Refer to specification section 32 1415 "Pavement Marking".

3.10 WHEEL STOPS

- A. Securely attach wheel stops into pavement with not less than two galvanized steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 FIELD QUALITY CONTROL

- A. Testing and inspecting: Owner may secure a testing firm to perform and determine compliance with specified requirements and AI MS-2.

3.12 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill. Refer to Due Care Plan for Constructions for additional requirements.

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1. Do not allow excavated materials to accumulate on-site.

END OF SECTION

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SECTION 321313

CEMENT CONCRETE PAVEMENTS, CURBS, AND GUTTERS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. All paving materials and construction methods shall conform to the current standards and specifications of the Michigan Department of Transportation. Where these specifications are less stringent than the requirements of MDOT, the MDOT standards shall govern.

1.2 SUMMARY

- A. This Section includes exterior cement concrete pavement for the following:
 - 1. Driveways and drive aisles.
 - 2. Parking lots.
 - 3. Curbs and gutters.
 - 4. Sidewalks and platforms.
 - 5. Wheel stops.
- B. Related Sections include the following:
 - 1. Division 31 1415 Section "Pavement Marking".
 - 2. Division 31 2000 Section "Earth Moving" for subgrade preparation, grading, and subbase course.

1.3 PERFORMANCE REQUIREMENTS

- A. Refer to MDOT's current Standard Specifications for Construction.

1.4 SUBMITTALS

- A. Submit aggregate and concrete mix designs for review. Contractor shall confirm that the materials provided meet the required specifications and provide material certification to the engineer. Material certification shall state that the products meet or exceed the requirements indicated on the plans and the requirements of the regulating authority.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer with at least three (3) years in business who has completed pavement work similar in material, design, and extent to that indicated for this Project.
- B. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment and approved by authorities having jurisdiction or the DOT of the state in which Project is located.
 - 1. Manufacturer must be certified according to the National Ready Mix Concrete Association's Plant Certification Program.

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- C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.
- D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.

1.6 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Do not place concrete when base is wet or frozen. Protect concrete pavement from damage by rain or inclement weather.
- C. Protect the concrete from freezing until it attains a compressive strength of at least 1,000 PSI. Do not place concrete pavement until the ambient air temperature away from artificial heat is at least 25 degrees Fahrenheit and rising. At the time of concrete placement, ensure a concrete temperature from 45 degrees Fahrenheit to 90 degrees Fahrenheit.

PART 2 PRODUCTS

2.1 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
 - 1. Use flexible or curved forms for curved conditions.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces.

2.2 STEEL REINFORCEMENT

- A. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated flat sheets, unfinished.
- B. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed billet steel, unfinished.
- C. Epoxy-Coated Reinforcement Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, deformed bars.
- D. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60, deformed bars; assembled with clips.
- E. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60. Cut bars true to length with ends square and free of burs.
- F. Epoxy-Coated Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, plain steel bars.
- G. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.

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- H. Hook Bolts: ASTM A 307, Grade A, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against pavement form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.
 - I. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiberreinforced concrete of greater compressive strength than concrete.
 - J. Epoxy Repair Coating: Liquid two-part epoxy repair coating, compatible with epoxy coating on reinforcement.
- 2.3 CONCRETE MATERIALS
- A. General: Use the same brand and type of cementitious material from the same manufacturer throughout the Project. All material to meet current MDOT specifications.
- 2.4 CURING MATERIALS
- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry where indicated on Contract Documents.
 - B. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
 - C. White Membrane Curing Compound: ASTM C 309, Type 2.
- 2.5 RELATED MATERIALS
- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.
 - 1. Thickness: ½ inch minimum and thicker where indicated.
 - B. Coloring Agent: See Landscape Architecture Specifications
 - C. Wheel Stops (use only if indicated on the plans): Precast, air-entrained concrete; 2500-psi minimum compressive strength; approximately 6 inches high, 9 inches wide, and 84 inches long. Provide chamfered corners and drainage slots on underside, and provide holes for dowelanchoring to substrate
 - 1. Dowels: Galvanized steel, diameter of 3/4 inch, minimum length 18 inches.
 - D. Slip-Resistive Aggregate Finish: See Landscape Architecture Specifications
 - E. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
 - F. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements.

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2.6 CONCRETE MIXES

- A. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes.
- B. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the trial batch method.
- C. Concrete mix design shall meet the requirements of MDOT, with compressive strength, maximum water-cementitious materials ratio, slump limit, and air content per MDOT specifications. Maximum aggregate size in coarse aggregate gradation shall be 1.5 inches.
- D. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements for concrete exposed to deicing chemicals.
- E. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content meeting requirements of MDOT.
- F. Use appropriate treatment per MDOT specifications where concrete will be placed under freezing conditions. Obtain approval of Engineer prior to placing concrete in freezing conditions. Concrete accelerators may be used in cold temperatures as noted below:
 - 1. In concrete with steel reinforcement, a non-chloride accelerating admixture may be used. Admixture product shall be approved by MDOT per their current Qualified Products List (QPL) and the dosage shall be per manufacturer's instructions. Admixtures containing calcium chloride shall not be used in concrete containing steel reinforcement.
 - 2. In concrete without steel reinforcement, calcium chloride concrete accelerators may be used and shall meet the requirements of MDOT Specification Section 903.04.
- G. Coloring Agent: See Landscape Architecture Specifications

2.7 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94 and ASTM C 1116.
 - 1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Comply with requirements and measure, batch, and mix concrete materials and concrete according to ASTM C 94. Mix concrete materials in appropriate drum-type batch machine mixer.

PART 3 EXECUTION

3.1 PREPARATION

- A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction and repair as required.
- B. Verify that grades are correct.

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3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations.
- B. Clean forms after each use and coat with form release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating reinforcement and with recommendations in CRSI's "Placing Reinforcing Bars" for placing and supporting reinforcement.
- B. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- C. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- D. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap to adjacent mats.

3.4 JOINTS

- A. General: Construct construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.
- B. At all locations where new concrete abuts existing concrete, building wall, or supported slabs, place expansion joint and joint sealant.
- C. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour, unless pavement terminates at isolation joints.
 - 1. Provide preformed galvanized steel or plastic keyway-section forms or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
- D. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where required.
 - 1. Terminate joint filler 1 inch below finished surface to allow placement of joint sealant.
 - 2. Joint sealant is required for all projects even if not indicated on the plans.
- E. Expansion Joints: Place 1 inch (25 mm) wide expansion joints at maximum 40 foot intervals, if not indicated on drawings. Joints to be full depth of pavement. Place joint sealant at all expansion joints.

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- F. Install dowel bars and support assemblies at joints if indicated on the plans. Lubricate or asphaltcoat one-half of dowel length to prevent concrete bonding to one side of joint.
 - G. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas. Construct ¼ inch wide contraction joints for a depth equal to at least one-third of the concrete thickness. Maximum spacing of contractions joints shall be 8'.
 - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 3/8-inch (10-mm) radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.
 - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
 - 3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt coat one-half of dowel length to prevent concrete bonding to one side of joint.
 - H. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to the following radius.
 - 1. Radius: 3/8 inch (10 mm).
- 3.5 CONCRETE PLACEMENT
- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcement steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
 - B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.
 - C. Do not add water to concrete during delivery, at Project site, or during placement.
 - D. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete according to recommendations in ACI 309R.
 - E. Cold-Weather Placement: Comply with ACI 306.1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - F. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R when hotweather conditions exist.
- 3.6 CONCRETE FINISHING
- A. General: Wetting of concrete surfaces during screeding, initial floating, or finishing operations is prohibited.

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- B. Float Finish: Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots, and fill low spots.
 - 1. Area Paving: Light broom, texture perpendicular to pavement direction.
 - 2. Curbs and Gutters: Light broom, texture parallel to pavement direction.
 - 3. Direction of Texturing: Parallel to pavement direction.
 - 4. Inclined Vehicular Ramps: Heavy broomed perpendicular to slope.
 - 5. Place sealer on exposed concrete surfaces immediately after finishing. Apply in accordance with manufacturer's instructions.
 - C. Provide detectable warning surface at all handicap ramps to meet ADA requirements in accordance with ANSI sections 406.13 and 705.
- 3.7 CONCRETE PROTECTION AND CURING
- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and follow recommendations in ACI 305R for hot-weather protection during curing.
 - B. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions.
 - C. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
 - 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.
 - 2. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions.
- 3.8 PAVEMENT TOLERANCES
- A. Comply with tolerances of ACI 117 and as follows:
 - 1. Elevation Variation: 1/4 inch.
 - 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
 - 3. Surface Variation: Gap below 10-foot- long, unlevelled straightedge not to exceed 1/4 inch.
 - 4. Maximum cross slope for walks, ramps, platforms: 2%
 - 5. Maximum longitudinal walk slopes not requiring landings and handrails: 5%
 - 6. Maximum longitudinal ramp slopes: 8.33% (1 on 12 slope)

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3.9 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Engineer.
- B. Allow concrete pavement to cure for 28 days and be dry before starting pavement marking.
- C. Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.
 - 1. If indicated on the plans, spread glass beads uniformly into wet pavement markings at a rate of 6 lb/gal.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement according to requirements specified.
- B. Testing Services: Testing shall be performed according to the following requirements:
 - 1. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test. Cylinders shall be molded and stored for laboratory-cured test specimens unless field-cured test specimens are required.
 - 2. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd., but less than 25 cu. yd., plus one set for each additional 50 cu. yd. One specimen shall be tested at 7 days and two specimens at 28 days; one specimen shall be retained in reserve for later testing if required.
- C. Test results shall be reported in writing to Engineer, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in pavement, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- D. Additional Tests: Testing agency shall make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

3.11 REPAIRS AND PROTECTION

- A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements as directed by the Engineer.

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- B. Remove and replace concrete sidewalks and/or ramps that do not comply with maximum slopes indicated in Section 3.8A above.
- C. Protect concrete from damage. Exclude traffic from pavement for at least fourteen (14) calendar days after placement.

END OF SECTION

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SECTION 32 1415

PAVEMENT MARKINGS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.
- B. These specifications apply to private, on-site pavement marking. All pavement markings within public rights-of-way must comply with the standards of the regulating agency.

1.2 SUMMARY

- A. The work under this section includes but is not necessarily limited to the furnishing and installation of all materials necessary for placing pavement markings as indicated on drawings and specifications.
 - 1. Markings on concrete pavement areas.
 - 2. Markings on asphalt pavement areas.
 - 3. Markings on existing concrete or asphalt areas.
 - 4. Markings on resurfaced existing pavements.
- B. Related Sections include the following:
 - 1. Division 32 1216 Section "Hot-Mix Asphalt Concrete Paving."
 - 2. Division 32 1313 Section "Cement Concrete Pavements, Curbs and Gutters."

1.3 QUALITY ASSURANCE

- A. MDOT Specifications: Unless otherwise indicated on drawings or herein specification, all work under this section shall be performed in accordance with the current MDOT Standard Specifications for Highway Construction.
- B. Physically Handicapped: All marking shall be done in accordance with ADA Requirements.
- C. Paint Containers: Each paint container shall be plainly marked, with a durable, weather resistant marking, showing the name and address of manufacturer or vendor, description of material, batch number, date of packaging and volume and weight of contents.
- D. Use only personnel completely trained and experienced in installation of materials and equipment.

1.4 SUBMITTALS

- A. Product Data, shop drawing submittals are not required. Contractor shall confirm that the materials provided meet the required specifications and provide material certification to the engineer. Material certification shall state that the products meet or exceed the requirements indicated on the plans and the requirements of the regulating authority.

1.5 PRODUCT HANDLING

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- A. Protection: Use all means necessary to protect materials before, during and after installation and to protect the installed work and materials of all other trades.
- B. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the approval of the architect at no additional cost to owner.

PART 2 PRODUCTS

2.1 GENERAL

- A. All materials and products for work under this section shall conform to current MDOT Standard Specifications for Highway Construction.

2.2 PAVEMENT MARKING PAINT

- A. Pavement marking paint shall be fast dry and comply with MDOT's current Standard Specifications for Highway Construction. Material shall be selected from MDOT's current Qualified Products List per spec section 811.03D1: Waterborne, Liquid Pavement Marking Material
- B. Provide required colors for all physically handicapped markings, complying with governing agencies having jurisdiction.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

- A. Inspection: Prior to all work of this section, carefully inspect installed work of all trades and verify all such work is complete to the point where installation may properly commence. Verify all pavement markings may be installed in accordance with all pertinent codes and regulations, authorities having jurisdiction and referenced standards.
- B. Discrepancies: In the event of discrepancy, immediately notify the architect. Do not proceed with installation in areas of discrepancies until all have been fully resolved.

3.2 SURFACE PREPARATION

- A. Cleaning: Prior to application of pavement marking, it shall be marking contractor's responsibility that pavement surfaces are clear, dry, and free of all foreign materials.
- B. New pavement curing new bituminous wearing surface shall be in place for period of not less than fourteen days prior to application of Fast Dry pavement markings.

3.3 CONSTRUCTION METHODS

- A. Application: Pavement markings shall be solid 4" wide yellow lines and laid out as indicated on drawings. Paint shall be applied uniformly at a minimum rate of sixteen gallons per mile for single 4" solid line. Markings shall be applied so that they adhere adequately to surface.

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- B. Protection of wet paint shall be responsibility of contractor. Markings obliterated by traffic shall be retraced at contractor's expense.

3.4 DEFECTIVE WORK

- A. Improper location: Improperly located markings shall be removed at contractor's expense in a manner acceptable to architect and reapplied in correct locations at contractor's expense.
- B. Material shortage: Markings which are applied with material shortages shall be properly reapplied at contractor's expense.

3.5 CLEAN UP

- A. Upon completion of the work of this section, remove all rubbish, trash and debris resulting from work of this section. Leave site in neat and orderly condition.

END OF SECTION

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SECTION 329200
FINE GRADING, LAWN SEEDING and SITE STABILIZATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide all fine grading and seeding where shown on Drawings, as specified herein and as necessary for a complete and proper installation.
- B. Work shall include but not be limited to:
 - 1. Placing topsoil, amended soil and fine grading for lawn and planting beds
 - 2. Lawn seeding and fertilizing
 - 3. Sodding

1.2 DEFINITIONS

- A. When the phrase "lawn" is used in the specifications, it refers to areas permanently seeded with turfgrass.
- B. When the phrase "planting bed" is used in the specifications, it refers to areas of installation of trees, shrubs, perennials, ornamental grass, groundcover, plugs, and bulbs that are NOT within green stormwater infrastructure areas.
- C. Definition of Landscape Maintenance and Guarantee Period: Refer to 329320 Landscape Maintenance and Guarantee.

1.3 RELATED DOCUMENTS

- A. Attention is directed to Bidding and Contracting requirements, drawings and general provisions of the Contract, including General Conditions, which are hereby made part of this section.
- B. Related sections:
 - 1. Soil and Erosion Control 311018
 - 2. Green Stormwater Infrastructure 312400
 - 3. Planting 329310
 - 4. Landscape Maintenance and Guarantee 329390

1.4 REFERENCE SPECIFICATION

- A. AOSA -Association of Official Seed Analysis: Rules for testing Seeds, Journal of Seed Technology, 1991 Edition
- B. TAPPI-Technical Association of the Pulp and Paper Industry
- C. AOAC - Official Methods of Analysis, Association of Official Analytical Chemists.
- D. Materials and Work covered under this Section shall be in accordance with MDOT (2022 edition), Wayne County standards and specifications unless otherwise indicated. If a conflict exists between specifications, the more rigorous shall govern.

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1.5 QUALITY ASSURANCES

- A. Soil amendments: Copies of invoices shall be provided to the CONSULTANT. Samples must be provided if requested by the CONSULTANT.
- B. Seed: Provide the CONSULTANT with manufacturer's certification of compliance to the Specifications prior to seeding.
- C. The CONTRACTOR shall notify the CONSULTANT of seed sources 30 days after the contract award.
- D. CONTRACTOR shall review seed sources with CONSULTANT prior to ordering and shall submit an invoice following purchase and delivery of the seed.
- E. Installation of seed shall be carried out by CONTRACTOR and their employees who are thoroughly experienced and skilled in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this section. The CONTRACTOR shall have a minimum of five (5) years documented experience in comparable work.
- F. Grading and seeding layout shall be reviewed by the CONSULTANT prior to completion.

1.6 SUBMITTALS

- A. The CONTRACTOR shall submit to the CONSULTANT sources for seed 30 days after contract award.
- B. The CONTRACTOR shall submit to the CONSULTANT a plan and schedule for seeding at least two (2) weeks prior to the scheduled commencement of work.
- C. The CONTRACTOR shall submit to the CONSULTANT results of the soils analysis and starter fertilizer recommendation dictated in TOPSOIL section of this Specification.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Soil amendments shall be kept dry.
- B. Seed shall be delivered in original sealed containers, labeled in accordance with State Regulations and the US Department of Agriculture Rules and Regulations under the Federal Seed Act. Seed shall be stored in such a manner that it will be protected from damage by heat, moisture, rodents, or other causes.

1.8 SEEDING TIME

- A. Permanent lawn seeding shall be done between May 1 and June 15, or between August 15 and September 15 or as otherwise approved by the CONSULTANT.
- B. Erosion control seed can be seeded in the fall prior to the spring planting or within the same planting season, as conditions necessitate for erosion control and establishment of the permanent seed matrices.

PART 2 - PRODUCTS

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2.1 STARTER FERTILIZER

- A. Starter fertilizer for lawn seed and sod: Starter fertilizer shall be Milorganite (6-2-0), available through Rhino Seed and Landscape Supply, Brighton, Michigan (800.482.3130), or approved substitute.

2.2 PERMANENT LAWN SEED

- A. Apply lawn seed at a species rate of pounds per acre as indicated on the Drawings.
- B. Seed Supplier: Seed is available through Rhino Seed and Landscape Supply, Brighton, Michigan (800.482.3130) or approved substitute.

2.3 EROSION CONTROL SEED

- A. Apply erosion control seed at a species rate of pounds per acre as indicated in the contract documents.
- B. Seed sources for the erosion control seed are available through Rhino Seed and Landscape Supply, Brighton, Michigan (800.482.3130).

2.4 MULCH for LAWN SEED-DRY

- A. Material shall be straw. It shall be natural and suited for horticultural use and not contain lumps, roots or other foreign matter over one inch in diameter. It shall be free of noxious weeds. Mulch shall not contain more than 35-percent moisture by weight.

2.5 MULCH for LAWN -HYDROSEED

- A. Material shall be RhinoTurf or AmTurf Green Star Plus, paper mulch with binder or approved substitution.

2.6 HYDOSEED TURF SLURRY MIX

- A. Mix shall consist of:
 - 1. Fertilizer: 1300 lbs per acre
 - 2. Mulch: 2000 lbs per acre
 - 3. Seed: 12 lbs per 1,000 square feet or 523 lbs. per acre

2.7 WATER

- A. Source: If not available on site, shall be provided by the CONTRACTOR.
- B. Quality: Water supplied by the CONTRACTOR shall be free of substances harmful to plant growth.

2.8 TOPSOIL

- A. Imported topsoil shall be friable sandy loam capable of supporting optimal plant growth and development. It shall be free of clay lumps, subsoil, invasive weeds and seeds, stones, sticks and other extraneous materials.

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- B. Quantity: The CONTRACTOR shall be responsible for estimating the quantity imported topsoil necessary to obtain the specified depth of topsoil to be re-spread. The CONTRACTOR shall report any discrepancy between work on the Plans and in the Specifications to the CONSULTANT.
- D. Analysis for existing and any necessary imported topsoil for lawn and planting beds shall be done at the CONTRACTOR'S expense and shall be submitted to CONSULTANT for approval prior to use.
- E. The structural topsoil analysis for lawn and planting beds shall be within the listed parameters:
 - 1. Clay content: 10 -20%
 - 2. pH range: 6.5 – 8.0
 - 3. Organic matter content: 3-10%: Compost may be added as an amendment to satisfy organic matter content percentages.
 - 4. Soil Textural Analysis: defines the percentages of sand, silt, and clay and classifies topsoil as a sandy loam.
 - 5. Testing for topsoil for lawn and planting beds may be performed through A&L Great Lakes Laboratories, Inc., Fort Wayne Indiana 260.483.4759.
- F. Sample: 1-gallon sample of topsoil that represents topsoil to be used on actual project in a sealed plastic bag.

2.9 COMPOST

- A. Compost shall be used only from a facility registered within the State of Michigan, or as approved by CONSULTANT. At least fourteen (14) working days in advance of construction and before delivery of compost, Contractor must submit the following to the Engineer for approval:
- B. Sample: 1-gallon sample of compost that represents compost to be used on actual project in a sealed plastic bag.
- C. Technical data sheet showing the following:
 - 1. A statement that the compost meets federal and state health and safety regulations.
 - 2. A compost technical data sheet from the vendor of the compost. The analysis and report must be consistent with the sampling and reporting requirements of the US Composting Council Seal of Testing Assurance (STA) program. The date of analysis shall be no more than ninety (90) calendar days prior to the date of submittal.
- D. Quantity: The CONTRACTOR shall be responsible for estimating the quantity of compost necessary to obtain the necessary organic content of the topsoil should the testing for organic matter be below the specified amount. The CONTRACTOR shall report any discrepancy between work on the Plans and in the Specifications to the CONSULTANT.

2.10 AMENDED SOIL

- A. Amended soil for planting beds shall be prepared on site by mixing three (3) parts topsoil, one (1) part compost and adding starter fertilizer for planting beds at the recommended rate.

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2.11 EROSION CONTROL BLANKET

- A. Erosion control blanket shall be North American Green Straw Erosion Control Blanket S150 BN, 100% biodegradable, jute netted or approved substitution.
- B. Pegs shall be of sound wood and sized per MDOT Standard Specifications, latest edition.
- C. Erosion control blanket supplier: Erosion control blanket is available through Price and Company, Inc., Wyoming, Michigan (616.530.8230).

2.12 SOD

- A. Sod shall meet MDOT standards and specifications for Class A Sod.
- B. Type: Kentucky Bluegrass Blend
- C. Quality:
 - 1. Dense, healthy, field-grown on mineral topsoil (less than 10% organic content) with the grass having been mowed at one-inch height before lifting from field.
 - 2. Dark green in color, relatively free of thatch, free from diseases, weeds and harmful insects.
 - 3. Reasonable free of objectionable grassy and broadleaf weeds. Sod will be considered weed free if no more than ten such weeds are found per hundred square feet of sod.
 - 4. Sod will be rejected if found to contain the following weeds: Bermuda grass, bent grass, perennial sorrel, and brome grass.
 - 5. Sod grown on peat will not be approved.

2.13 HERBICIDES

- A. Materials shall comply with Local, State and Federal regulations.
- B. Common IPM (Integrative Pest Management) practices shall be followed.
- C. Herbicide-A. Glyphosate, a nonselective herbicide shall be used to eradicate existing vegetation and for selective weed control. It shall be used according to the manufacturer's label.
- D. Herbicide-B. Sethoxydim, a selective herbicide shall be used to selectively remove invasive grass and weeds from seeding and planting beds (if not adjacent to water). It shall be used according to the manufacturer's label.
- E. Herbicide-C. Rodeo, a non-selective herbicide shall be used to eradicate existing vegetation in seeding and planting beds adjacent to open water or in the wetlands. It shall be used according to the manufacturer's label.

PART 3 – EXECUTION

3.1 SUBGRADE PREPARATION

- A. In lawn and landscape bed areas: Upon completion of rough grading, Rototill or scarify

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surface of subgrade to a depth of 6 inches with the teeth of the backhoe or loader bucket, or other suitable device. All aggregate base must be removed prior to the placing of topsoil/ amended soils. Bring subgrade to line, grade, and elevations indicated. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction before the placing of topsoil or amended soil.

3.2 PLACING TOPSOIL and AMENDED SOIL and FINE GRADING

- A. Repair topsoil/ amended soil as directed by the CONSULTANT so that finish grades are met.
- B. For lawn areas, topsoil shall be placed to a minimum depth of six (6) inches, so that the finish surface is a fine seedbed, varying not more than one (1) inch in ten (10) feet.
- C. For planting beds, amended soil shall be placed to a minimum depth of eighteen (18) inches, so that the finish surface is a fine seedbed, varying not more than one (1) inch in ten (10) feet.
- D. Final grades will be reviewed by the CONSULTANT prior to demobilization/completion.

3.3 HYDROSEEDING FOR LAWN

A. Mixing:

- 1. Mix location: Perform slurry preparation at job site.
- 2. Adding water: Add water to the tank when the engine is at half throttle. When the water level has reached the height of the agitator shaft, establish good re-circulation and add seed.
- 4. Seed: Do not allow seed to remain fore than 30 minutes is slurry.
- 5. Fertilizer: Add fertilizer without mulch. Commence spraying immediately when the tank is full.
- 6. Mulch: Apply mulch in a separate operation after seed and fertilizer have been applied.

B. Application:

- 1. Apply specified slurry mix in a sweeping motion to form a uniform mat at the specified rate.
- 2. Keep hydroseeding within designated areas and keep from contact with other plant materials.
- 3. Apply seed and mulch in two separate operations.

3.4 SEEDING AND FERTILIZING FOR LAWN

A. Application:

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1. Sow the seed using a mechanical seeder such as a lawn maker or brillion. A cultipacker or approved similar equipment may be used to cover the seed and form the seedbed in one operation.
2. Sow at the species rate of pounds per acre as indicated on the drawings.
3. Lines of seed shall be perpendicular to slopes to reduce rapid surface water run-off. If this option is chosen fertilize prior to seeding operations.

B. Fertilizing:

1. Apply starter fertilizer with a mechanical spreader prior to seeding operation as necessary to promote optimal growth.
2. Thoroughly incorporate fertilizer into topsoil to a depth of two (2) inches.
3. Immediately before sowing lawn seed, CONTRACTOR shall rework the surface until it is fine, pulverized seed bed, varying not more than one (1) inch in ten (10) feet.

3.5 SODDING

- A. Sod shall be installed at locations indicated on Plans. In addition, an approved sod may be used in lieu of seed at the CONTRACTOR's option and expense if he/she feels it is in the best interest of lawn establishment.
- B. Scarify subgrade, spread topsoil. Fertilize topsoil area to be sodded with starter fertilizer as necessary to promote optimal growth. Incorporate fertilizer into upper three (3) to four (4) inches of soil.
- C. Timing:
 1. Install sod within 24 hours of delivery.
 2. Sod not transplanted within 24 hours of delivery will be rejected.
- D. Rolling Sod Bed: Roll amended soil with 200 pound water-ballast roller.
- E. Moistening Sod Bed: After all unevenness in the soil surface has been corrected, lightly moisten the soil immediately prior to laying the sod.
- F. Laying the sod:
 1. Lay the first row of sod in a straight line, with subsequent rows parallel to and tightly against each other, with no spaces between strips.
 2. Stagger lateral joints.
 3. Sodded areas shall be flush with adjoining existing lawn or seeded areas.
 4. Do not stretch or overlap sod.
 5. Butt all joints tightly to eliminate all voids.

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6. Use a sharp knife to cut sod to fit curves.
- G. Tamping and rolling sod:
 1. Thoroughly tamp and roll sod with a 200 pound water-ballast roller to make contact with sod bed.
 2. Roll each entire section of completed sod.
- H. Slopes of 3:1 or greater
 1. Lay sod with staggered joints secure by pegs driven through sod into soil until pegs are flush with turf.
 2. Space pegs 18 inches on center.
 3. Pegs to be one (1)-inch square x six (6)-inch length of lath.
- I. Watering: Thoroughly water sod immediately after installation to wet the underside of the new sod pad and the soil immediately below to a depth of six (6) inches.

3.6 LAWN WEEDS

- A. Invasive grasses such as crabgrass, smooth brome, reed canary, quack grass or other invasive grasses and/or forbs shall be spot controlled beginning in May with Herbicide-A (or approved substitution) until the end of the first full growing season and/or before the plants set seed. Lawn herbiciding maintenance shall not threaten any adjacent planting beds. Alert the CONSULTANT if a conflict between lawn maintenance and the health of the planting beds exists.

3.7 EROSION CONTROL BLANKET INSTALLATION

- A. Install erosion control blanket per manufacturer's specifications in locations indicated on Plans. In addition, erosion control blanket shall be installed where the CONTRACTOR feels it necessary to stabilize the site. Additional blanket beyond what is indicated on the Plans shall be provided and installed at the expense of the CONTRACTOR.
- B. Begin at top of the slope by anchoring the blanket in a 6-inches deep x 6-inches wide trench. Backfill and compact the trench after staking.
- C. Roll the blankets down the slope in the direction of the water flow.
- D. The edges of parallel blankets must be staked with approximately two (2)-inch overlap. When blankets must be spliced down the slope, place blankets end over end (shingle style) with approximately six (6)-inch overlap. Stake through overlapped area, approximately 12 inches apart.
- E. In general, stake blanket approximately one (1) stake per one (1) square foot.

3.8 MULCHING

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- A. Lawn seeded areas to be mulched shall be mulched per MDOT Specifications, latest edition.

3.9 ESTABLISHMENT AND ACCEPTANCE: LAWN

- A. Establishment of a dense stand of perennial lawn, free from mounds and depressions is the responsibility of the CONTRACTOR. Any part of the area that fails to show a uniform germination shall be re-seeded, and such re-seeding shall continue until a dense lawn is established.
- B. Watering: The CONTRACTOR shall keep seeded areas moist for optimum plant growth (1 1/2" of total water per week, including rainfall) until the grass is four (4) inches high typical.
- C. Erosion shall be repaired by the CONTRACTOR.
- D. Bare spots over three (3) percent of the area or greater than one (1) square foot in size will not be allowed, unless otherwise approved by the CONSULTANT.
- E. Protection from traffic and erosion in newly seeded areas is the responsibility of the CONTRACTOR. Safety fences and/or silt fence with appropriate signage may be used at the CONTRACTOR's expense until the lawn is fully established.
- F. Initial mowing of the lawn area shall take place when grass is four (4) inches high and shall be the responsibility of the CONTRACTOR. Cutting height shall be three (3) inches minimum. Do not cut more than 1/3 of grass blade height.
- G. An approved sod may be used at the CONTRACTOR'S option and expense if he/she feels it is in the best interest of lawn establishment.
 - 1. Fertilize topsoil area to be sodded with starter fertilizer recommended by testing agency described in the TOPSOIL section of this specification.
- H. Acceptance will be when all the above specifications have been met.

END OF SECTION

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SECTION 329310

PLANTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide Planting where shown on drawings as specified herein, and as needed for a complete and proper installation.
- B. Work shall include:
 - 1. Tree and shrub planting
 - 2. Ornamental grass, perennial, bulb and groundcover planting
 - 3. Soil amendments and mulch application

1.2 RELATED DOCUMENTS

- A. Attention is directed to Bidding and Contracting requirements, drawings and general provisions of the Contract, including General Conditions and Division 1 Specification sections, which are hereby made part of this section.
- B. Related Sections:
 - 1. Fine Grading, Lawn Seeding, and Site Stabilization 329200
 - 2. Green Stormwater Infrastructure 312400
 - 3. Landscape Maintenance and Guarantee 329390

1.3 DEFINITIONS

- A. When the phrase "planting bed" is used in the specifications, it refers to areas of installation of trees, shrubs, perennials, ornamental grass, groundcover, plugs, and bulbs that are NOT within green stormwater infrastructure areas.
- B. When the phrase "Stormwater Planting" is used in the specifications it refers to areas of installation of trees, shrubs, perennials, ornamental grass, groundcover, plugs, and bulbs that ARE WITHIN green stormwater infrastructure areas.
- C. Definition of Landscape Maintenance and Guarantee Period: The Maintenance and Guarantee Period begins upon written notification of substantial completion and continues for a period of two years.

1.4 REFERENCE SPECIFICATIONS

- A. AOSA -Association of Official Seed Analysis:
- B. Rules for testing Seeds, Journal of Seed Technology, 1991 Edition
- C. TAPPI-Technical Association of the Pulp and Paper Industry
- D. AOAC - Official Methods of Analysis, Association of Official Analytical Chemists.

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- E. Materials and Work covered under this Section shall be in accordance with MDOT (2022 edition), Wayne County standards and specifications unless otherwise indicated. If a conflict exists between specifications, the more rigorous shall govern.

1.5 QUALITY ASSURANCE

- A. CONTRACTOR shall provide CONSULTANT with a list specifying sources of plant material.
- B. Inspection: The CONSULTANT may inspect plants at place of growth or on site prior to planting. Rejected material shall be immediately removed from site. Material damaged during planting may be rejected after planting. Material approved at place of growth, but damaged during transportation may also be rejected.
- C. Installation of plants shall be carried out by Contractors and their employees who are thoroughly experienced and skilled in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this section. The CONTRACTOR shall have a minimum of five (5) years documented experience in comparable work.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Plant material delivery shall be the same day as planting. No plants shall be stored at the site without permission of the CONSULTANT. Plants shall be carefully loaded and unloaded so as not to damage branching or root mass. Dropping of material will not be allowed. Plants in full leaf shall be thoroughly wetted down and completely covered with a wet tarp during transportation.
- B. All plant roots must be kept in a moist condition.
- C. Digging and Handling Plant Material: Digging shall be during the dormant season, preferably between 1 October and 1 May. Plant material which is poorly packed, or which arrives with the roots in a dry condition, as a result of improper packing, delay in transit, or from any other cause, will not be accepted. Stock shall be handled in such a manner that the roots shall remain intact, the branches unbroken, and the bark intact and not loosened from the wood. Stock shall be protected from drying and from temperatures below 50°F and in excess of 90°F prior to planting.

1.7 SUBMITTALS

- A. The CONTRACTOR shall submit to the CONSULTANT sources for all plant material 30 (thirty) days after contract award.
- B. The CONTRACTOR shall submit to the CONSULTANT all proposed plant substitutions 30 (thirty) days after contract award.
- C. Topsoil and Compost: The CONTRACTOR shall submit to the CONSULTANT physical samples and results of the soils analysis dictated in TOPSOIL and COMPOST section of this specification.
- D. The CONTRACTOR shall provide the CONSULTANT with a construction sequencing plan that proposes a method to establish stormwater planting areas prior to the

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activation of the on-site storm water or provides some method of diversion of that storm water until such time as the stormwater planting can establish itself.

1.8 PLANTING TIME

- A. Planting shall be done after May 15, but before September 15 or as otherwise approved by the CONSULTANT.
- B. Stormwater plantings may not be installed after September 15.

PART 2 - PRODUCTS

2.1 PLANTS

- A. Material shall be of the size, genus, species, variety and any other special designation as shown and scheduled for on the drawings, on the attached Proposal Form or in these Specifications. No substitution of species, variety or size shall be accepted without written approval from the CONSULTANT and OWNER. Plant material shall be nursery grown, under climatic conditions similar to those in the locality of the project.
- B. Quality: Plants shall comply with the recommendations and requirements of ANSI Z60.1 "American Standard for Nursery Stock." Plants shall be healthy, vigorous stock, grown in a recognized nursery in accordance with good horticultural practice and free of disease, insects, eggs, larvae and defects such as knots, sunscald, injuries, abrasions, or disfigurement.
 - 1. Plants balled with plastic burlap will not be accepted.
- C. Labeling: All plants shall be labeled with securely-attached waterproof tab bearing legible designation of botanical and common name.
- D. Formal arrangements if/where shown on planting plan shall have trees selected for uniform height and spread.

2.2 TOPSOIL

- A. Imported topsoil shall be friable sandy loam capable of supporting optimal plant growth and development. It shall be free of clay lumps, subsoil, invasive weeds and seeds, stones, sticks and other extraneous materials.
- B. Quantity: The CONTRACTOR shall be responsible for estimating the quantity imported topsoil necessary to obtain the specified depth of topsoil to be re-spread. The CONTRACTOR shall report any discrepancy between work on the Plans and in the Specifications to the CONSULTANT.
- D. Analysis for existing and any necessary imported topsoil for lawn and planting beds shall be done at the CONTRACTOR'S expense and shall be submitted to CONSULTANT for approval prior to use.
- E. The structural topsoil analysis for lawn and planting beds shall be within the listed parameters:
 - 1. Clay content: 10 -20%

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2. pH range: 6.5 – 8.0
3. Organic matter content: 3-10%: Compost may be added as an amendment to satisfy organic matter content percentages.
4. Soil Textural Analysis: defines the percentages of sand, silt, and clay and classifies topsoil as a sandy loam.
5. Testing for topsoil for lawn and planting beds may be performed through A&L Great Lakes Laboratories, Inc., Fort Wayne Indiana 260.483.4759.

- F. Sample: 1-gallon sample of topsoil that represents topsoil to be used on actual project in a sealed plastic bag.

2.3 FERTILIZER

- A. Fertilizer shall be slow release, at minimum 50% derived from a natural, organic source, 3-3-3 or approved substitution.

2.4 COMPOST

- A. Compost shall be used only from a facility registered within the State of Michigan, or as approved by CONSULTANT. At least fourteen (14) working days in advance of construction and before delivery of compost, Contractor must submit the following to the Engineer for approval:

- B. Sample: 1-gallon sample of compost that represents compost to be used on actual project in a sealed plastic bag.

- C. Technical data sheet showing the following:

1. A statement that the compost meets federal and state health and safety regulations.
2. A compost technical data sheet from the vendor of the compost. The analysis and report must be consistent with the sampling and reporting requirements of the US Composting Council Seal of Testing Assurance (STA) program. The date of analysis shall be no more than ninety (90) calendar days prior to the date of submittal.

2.5 AMENDED SOIL

- A. Amended soil for planting beds shall be prepared by mixing three (3) parts topsoil, one (1) part compost and adding starter fertilizer for planting beds at the recommended rate.

2.7 PRE-PLANTING SUPPORT

- A. Material for support through transplanting shock shall be Bio-Plex Technical Transplant Concentrate and Plant Enhancer or approved substitution. This product is available through Bio-plex, Inc., 1.800.441.3573

2.8 WATER

- A. Source: Source: If not available on site, shall be provided by the CONTRACTOR.
- B. Quality: Water supplied by the CONTRACTOR shall be free of substances harmful to plant growth.

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- C. Coordinate with irrigation contractor for system handoff. Irrigation maintenance, management, and scheduling shall be provided by the CONTRACTOR during the Landscape Maintenance and Guarantee Period.

2.9 MULCH

- A. Material around isolated trees and in planting bed areas shall be shredded hardwood bark free of weeds, soil, sticks or trash, and shall have a uniform appearance. A sample shall be approved by CONSULTANT prior to application.

- 1. Colored or dyed mulch will not be accepted.

2.10 LOCATION STAKES

- A. Stakes for plant locations shall be 1" X 2" X 3', and supplied by the CONTRACTOR.

PART 3 - EXECUTION

3.1 PLANTING SUPPORT

- A. If trees and/or shrubs are planted from May through August, or when there are drought conditions during September through April, the CONTRACTOR shall provide planting support to each balled and burlapped specimen with Bio-Plex Technical Transplant Concentrate and Plant Enhancer (per manufacturer's instructions on label) by means of:

- 1. A foliar application (through spray) upon receipt of trees and shrubs
 - 2. A root application (through tree gators) upon planting of trees and shrubs

3.2 LAYOUT

- A. Locations of trees, shrubs, perennials and groundcover shall be established by the CONTRACTOR according to plans.
- B. Locations for trees and shrubs shall be identified with stakes. Different species shall be clearly labeled and marked with different color ribbon, paint or permanent marker on the stake.
- C. Perennials, ornamental grasses shall be laid out in their containers on top of the ground.
- D. Groundcover zones shall be laid out by paint.
- E. Review: The CONTRACTOR shall notify the CONSULTANT when staking and layout is completed and allow two working days for modifications and notice to proceed with planting.

3.3 TREE and SHRUB PLANTING

- A. Balled and/or container stock as per detail:
 - 1. Set plants plumb.
 - 2. B&B STOCK:
 - a. Remove all bindings and burlap from top one half of ball and remove from site.

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- b. Cut wires from top half of basket and remove from site.
- c. Remove soil as necessary to expose the root flare prior to planting.
- d. Root prune girdling roots.

CONTAINER STOCK:

- a. Remove all containers and packaging material before planting and remove from site.
 - b. Scarify/ root prune girdling roots as necessary.
- 3. Backfill with amended soil. Water and foot compact at intervals. Do not damage root structure.
 - 4. Mulch to a depth as shown on the details and soak the mulch with water. Thoroughly soak root ball with water.
 - 5. Prune all dead wood at first live lateral bud in accordance with standard horticultural practices using sharp instruments cleaned frequently. If necessary, any additional pruning will be directed by the CONSULTANT. Do not prune terminal leader or branch tips. A plant's natural form shall not be compromised by any pruning activities. Promptly remove all pruned material from site.
 - 6. Remove all nursery applied tree wrap, tape or string from trunk and crown. Remove any tags or labels and remove from site.

3.4 ORNAMENTAL GRASSES, PERENNIAL and GROUNDCOVER PLANTING

A. Container stock as per detail:

- 1. Remove all containers and packaging material before planting and remove from site.
- 2. Set plants plumb.
- 3. Scarify/ root prune girdling roots as necessary.
- 3. Backfill with amended soil. Do not damage root structure.
- 4. Mulch to a depth as shown on the details and soak the mulch with water. Thoroughly soak root matter with water.

END OF SECTION

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SECTION 329390

LANDSCAPE MAINTENANCE AND GUARANTEE

PART 1 - GENERAL

1.1 SUMMARY

- A. The CONTRACTOR shall furnish all labor, materials, equipment, transportation, services and necessary appurtenant work as required to complete the work as shown on the Plans and/or as specified herein.
- B. Extent of work shall include but not be limited to:
 - 1. Removal of plant support and tags (if any)
 - 2. Weed Control
 - 3. Disease and Insect Control
 - 4. Pruning
 - 5. Mulching
 - 6. Watering/Irrigation
 - 7. Inspection and Maintenance of Green Stormwater Infrastructure
 - 8. Landscape Maintenance & Guarantee of Plant Material (for 24 periods)

1.2 DEFINITIONS

- A. Definition of Landscape Maintenance and Guarantee Period: The Landscape Maintenance and Guarantee period begins upon notice of substantial completion and continues until the end of the second growing season. The growing season is defined as the beginning of March through mid- November. If planting is not completed prior to the end of June, the Landscape Maintenance and Guarantee Period includes the remainder of that growing season plus the next two growing seasons.

1.3 RELATED DOCUMENTS

- A. Attention is directed to Bidding and Contracting requirements, drawings and general provisions of the Contract, including General Conditions, which are hereby made part of this section.
- B. Related Sections:
 - 1. Green Stormwater Infrastructure 312400
 - 2. Fine Grading, Lawn Seeding, and Site Stabilization 329200
 - 3. Planting 329310

1.4 REFERENCE SPECIFICATION

- A. AOSA -Association of Official Seed Analysis: Rules for testing Seeds, Journal of Seed Technology, 1991 Edition
- B. TAPPI-Technical Association of the Pulp and Paper Industry

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- C. AOAC - Official Methods of Analysis, Association of Official Analytical Chemists.
- D. Materials and Work covered under this Section shall be in accordance with MDOT (1996 edition), City of Detroit standards and specifications unless otherwise indicated. If a conflict exists between specifications, the more rigorous shall govern.

1.5 QUALITY ASSURANCE

- A. Maintenance of seed and plants shall be carried out by CONTRACTORS and their employees who are thoroughly experienced and skilled in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this section. The CONTRACTOR shall have a minimum of five (5) years documented experience in comparable work.

1.6 SCHEDULE

- A. Schedule: A minimum of one visit is required for each of the following time periods during the Landscape Maintenance and Guarantee period. During each visit, CONTRACTOR shall complete all necessary tasks to comply with the requirements outlined in these specifications.
 - 1. 1 March to 1 May
 - 2. 1 May to 1 June
 - 3. 1 June to 1 July
 - 4. 1 July to 1 August
 - 5. 1 August to 1 September
 - 6. 1 September to 1 October
 - 7. 1 November to 1 March
- B. Verification of visits, in the form of reports and certified payroll covering visits, shall be provided to the CONSULTANT AND OWNER.

1.7 MAINTENANCE SERVICE BY CONTRACTOR

- A. Comply with maintenance requirements in Part 3—Execution

1.8 SUBMITTALS

- A. A maintenance report shall be provided to the CONSULTANT AND OWNER for each visit during the maintenance and guarantee period. Reports should include a summary of work completed, evaluation of tree and plant health, a summary of bio-retention function, and stonework conditions. Include photographs, list herbicide application (if any), list weed pressure and types of weeds. Summarize plans/ next steps.

PART 2 – PRODUCTS

2.1 PESTICIDES & HERBICIDES

- A. Materials shall comply with Local, State and Federal regulations.

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- B. Common IPM (Integrative Pest Management) practices shall be followed. Before application of any herbicide the CONTRACTOR shall receive approval of the OWNER.

2.2 FERTILIZER

- A. Materials shall conform to the standards of the Association of Agricultural Chemists and shall comply with State and Federal regulations.
- B. Fertilizer for woody plants shall be an organic, slow release with a ratio of 3-1-2 or 3-1-1 or approved substitution.
- C. Starter fertilizer for perennial plants shall be an organic, slow release with a ratio of 3-3-3 or 3-1-1 or approved substitution. Apply prior to planting.

2.3 WATER

- A. Source: If not available on site, shall be provided by the CONTRACTOR.
- B. Quality: Water supplied by the CONTRACTOR shall be free of substances harmful to plant growth.
- C. Water plants thoroughly during droughts, more than ten (10) days of no measurable rain.

2.4 MULCH

- A. Mulch for plantings shall be shredded hardwood bark free of weeds, soil, sticks or trash, of a uniform appearance.
 - 1. Colored or dyed mulch will not be accepted.
 - 2. Apply at the depth specified on plans.

PART 3 – EXECUTION

3.1 MAINTENANCE OF GREEN STORMWATER INFRASTRUCTURE

- A. Inspection: Conduct a maintenance inspection to identify maintenance tasks required.
 - 1. Check curb cuts, sumps, swales, and inlets for accumulated sediment, leaves, and debris.
 - 2. Check for erosion, bare areas, and where mulch needs to be applied.
 - 3. Confirm there is not standing water still present in Green Stormwater Infrastructure after 48 hours.
 - 4. Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning.
 - 5. Check cobble swales, cobble drain outlets, and stonework for erosion, loose, or disturbed stone.
- B. Maintenance: Maintain planted and seeded areas of Green Stormwater Infrastructure during each visit in the required time periods described in 1.6 SCHEDULE.

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1. Remove trash and animal waste. Remove any dead or diseased plants and replace per Section 3.11
 2. Remove sediment in pretreatment cells and inflow points.
 3. In native seeding areas, reseed or stabilize bare spots exceeding two (2) square feet of vegetated area to prevent erosion.
 4. In stormwater planting areas, add mulch as necessary to maintain two (2) inches of shredded hardwood mulch.
 5. Execute herbiciding and weed control, and spring clean-up measures as described in this section.
 6. Re-set, chock, or add stone as necessary in cobble swales, cobble drain outlets, and other stonework.
- C. On an Annual basis, replace stone at curb curbs, inflow, weirs, and check dams. Blow out cleanouts using compressed air, high pressure water hose, or drain snake in practices that show evidence of clogged underdrain.
- D. Remove any accumulated sediment in curb cuts, inlets, pretreatment cells and run-on points at least once per year, or when sediment has accumulated to a depth of two (2) inches.

3.2 MAINTENANCE FERTILIZER APPLICATION

- A. Application shall be according to manufacturer's directions.
- C. Woody Plants
1. Maintenance Fertilizer application for woody plants shall occur in November of the Maintenance and Guarantee Period
 2. Top-dress at a rate of 1 pound of nitrogen per 1,000 square feet.

3.3 WEEDING

- A. Frequency shall be every visit.
- B. Remove immediately after weeding all weeds and debris from the site and dispose of in an environmentally sensitive manner.
- C. Methods: Weeds shall be removed by hand or by herbicide at the CONTRACTOR'S assessment. Before application of any herbicide the CONTRACTOR shall receive approval of the OWNER.

3.4 HERBICIDING

- A. Before application of any herbicide the CONTRACTOR shall receive approval of the OWNER.

3.5 DISEASE and INSECT CONTROL

- A. Monitoring for diseases and insects shall be the responsibility of the CONTRACTOR. The CONTRACTOR shall monitor all plants at all times for disease and insect problems.

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- B. Treatment shall take place in accordance with common IPM practices.
- C. Pesticides shall only be used when and where necessary as approved by the OWNER. Manufacturer's directions and precautions must be followed rigorously. Applicators shall be licensed by the State of Michigan. Applicators shall be knowledgeable in the application of pesticides and appropriate equipment used. Excess pesticides shall be properly removed from the site.

3.6 PRUNING

- A. Prune all dead wood at first live lateral bud in accordance with standard horticulture practices using sharp instruments cleaned frequently. Pruning shall enhance plant development and ornamental qualities. Do not prune terminal leader or branch tips. A plant's natural form shall not be compromised by any pruning activities.
- B. Additional pruning may be required at the request of the OWNER in order to decrease public liability factors.
- C. Remove immediately after pruning all dead, broken and diseased growth and other pruning debris from the site and dispose of in an environmentally sensitive manner.
- D. Plant material that is "topped" by the CONTRACTOR shall be replaced at the CONTRACTOR's expense.

3.7 ORNAMENTAL GRASS and PERENNIAL MAINTENANCE

- A. Timing: March maintenance visit.
- B. Cut all dead grass from previous season's growth to a height of two (2) to four (4) inches to promote new season's growth.
- C. Remove dead vegetation immediately after cutting all dead growth and other pruning debris from the site and dispose of in an environmentally sensitive manner.

3.8 MULCHING

- A. Monitoring: All mulch beds shall be reviewed in June and September of the Landscape Maintenance Period. Any beds that do not meet the following conditions shall be replenished.
 - 1. Depth shall be two (2) inches typical shredded hardwood bark for planting areas.
 - 2. Do not allow mulch to be deeper than three (3) inches.
 - 3. Keep mulch four (4) inches away from root collar of trees and shrubs.

3.9 REMOVAL of TREE SUPPORT and TAGS

- A. Repair all damaged guys and stakes during Maintenance Period
- B. Remove all stakes, guys, tags, and support material at the end of the Landscape Maintenance and Period and remove from site.

3.10 WATERING

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- A. Monitor all plants during site visits for water stress.
- B. Water as required to keep all plants in optimum health—this may exceed the time windows outlined in the schedule. For all plantings, apply water in a slow trickle to allow water to penetrate down into root zone of plant.
 - B. Stormwater plantings in the deepest ponding area may require more watering than other planting areas.
 - C. Adjust frequency and length of time for watering cycles according to changing soil and weather conditions. The CONTRACTOR is responsible for watering as necessary for plant survival at no additional cost to the OWNER.
 - D. Irrigation maintenance, management, and scheduling shall be provided by the CONTRACTOR during the Maintenance and Guarantee Period.

3.11 GUARANTEE of PLANT MATERIAL

- A. Responsibilities: The CONTRACTOR shall replace, at no cost to the OWNER, all dead vegetation during the Landscape Maintenance and Guarantee Period.
- B. Judgment of the plant's health will be the CONSULTANT'S or the OWNER'S.
- C. Planting methods shall be the same as specified herein and in the planting details unless directed by the CONSULTANT.
- D. Limits: Plants replaced during the Maintenance and Guarantee Period are only under guarantee during those periods.

3.12 FINAL ACCEPTANCE

- A. Final Acceptance of all plantings, green stormwater infrastructure, and landscape areas will be when all the above, including weed control requirements and requirements as specified in the EXECUTION Section of these specifications, have been met.

END OF SECTION

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SECTION 330500

COMMON WORK RESULTS FOR UTILITIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes, but not limited to the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Transition fittings.
 - 3. Dielectric fittings.
 - 4. Sleeves.
 - 5. Identification devices.
 - 6. Grout.
 - 7. Piped utility demolition.
 - 8. Equipment installation requirements common to equipment sections.
 - 9. Painting and finishing.
 - 10. Concrete bases.
 - 11. Metal supports and anchorages.
- B. Related Sections Include:
 - 1. Division 02 4116 Section "Structural Demolition."
 - 2. Division 02 4119 Section "Selective Structure Demolition."
 - 3. Division 05 5000 Section "Metal Fabrications."
 - 4. Division 09 9100 Section "Painting."
 - 5. Division 20 Sections "Basic Mechanical" for Common Work Results.

1.3 DEFINITIONS

- A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.
- B. Concealed 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.
- C. 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.

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1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Dielectric fittings.
 - 2. Identification devices.
- B. Samples of color, lettering style, and other graphic representation required for each identification material and device.
- C. Welding certificates.

1.5 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 Piped Utility 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.
- D. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.
- E. Comply with all local codes and agencies having jurisdiction.

1.6 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.

1.7 COORDINATION

- A. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.

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PART 2 PRODUCTS

2.1 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, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

- A. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A. 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 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 thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813. WAYNE STATE UNIVERSITY HEALTH SCIENCES RESEARCH BUILDING DETROIT, MICHIGAN Spalding DeDecker UD24011 WSU Health Sciences Research Building 2025-06-02 330500 - 4
- E. 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.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- G. Solvent Cements for Joining Plastic Piping:
 - 1. ABS Piping: ASTM D 2235.
 - 2. CPVC Piping: ASTM F 493.
 - 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 4. PVC to ABS Piping Transition: ASTM D 3138.
- H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

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2.4 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 and Smaller: Manufactured fitting or coupling.
 - 3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
 - 4. Aboveground Pressure Piping: Pipe fitting.
- B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solventcement-joint end.
 - 1. Manufacturers:
 - a. Eslon Thermoplastics.
- C. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
 - 1. Manufacturers:
 - a. NIBCO INC.
 - b. NIBCO, Inc.; Chemtrol Div.
- D. Flexible Transition Couplings for Underground Non pressure 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.

2.5 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
 - 1. Manufacturers:

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- a. Central Plastics Company.
 - b. Eclipse, Inc.
 - c. Epco Sales, Inc.
 - d. Hart Industries, International, Inc.
 - e. Watts Industries, Inc.; Water Products Div.
 - f. Zurn Industries, Inc.; Wilkins Div.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
1. Manufacturers:
- a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Div.
- E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, fullface- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
1. Manufacturers:
- a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
1. Manufacturers:
- a. a. Calpico, Inc.
 - b. b. Lochinvar Corp
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.
1. Manufacturers:
- a. Perfection Corp.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Victaulic Co. of America.

2.6 SLEEVES

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- A. Mechanical sleeve seals for pipe penetrations are specified in Division 22 Section "Mechanical" Common Work Results.
 - B. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
 - C. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
 - D. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.
 - 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.
- 2.7 IDENTIFICATION DEVICES
- A. General: Products specified are for applications referenced in other Division 02 Sections.
 - B. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.
 - 1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
 - 2. Location: Accessible and visible.
 - C. Stencils: Standard stencils prepared with letter sizes complying with recommendations in ASME A13.1. Minimum letter height is 1-1/4 inches for ducts, and 3/4 inch for access door signs and similar operational instructions.
 - 1. Material: Fiberboard or Brass.
 - 2. Stencil Paint: Exterior, oil-based, alkyd-gloss black enamel, unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior, oil-based, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.
 - D. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.
 - E. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressuresensitive vinyl type with permanent adhesive.
 - F. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers, extending 360 degrees around pipe at each location.
 - G. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.
 - H. Lettering: Manufacturer's standard preprinted captions as selected by Architect.
 - I. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

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1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.
- J. Plastic Duct Markers: Manufacturer's standard laminated plastic, in the following color codes:
 1. Green: Cold-air supply.
 2. Yellow: Hot-air supply.
 3. Blue: Exhaust, outside, return, and mixed air.
 4. Hazardous Material Exhausts: Use colors and designs recommended by ASME A13.1.
 5. Terminology: Include direction of airflow; duct service such as supply, return, and exhaust; duct origin; duct destination; and design flow.
- K. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils thick.
 1. Width: 1-1/2 inches on pipes with OD, including insulation, less than 6 inches; 2-1/2 inches for larger pipes.
 2. Color: Comply with ASME A13.1, unless otherwise indicated.
- L. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch sequenced numbers. Include 5/32-inch hole for fastener.
 1. Material: 0.032-inch-thick, polished brass or aluminum.
 2. Material: 0.0375-inch-thick stainless steel.
 3. Material: 3/32-inch-thick plastic laminate with 2 black surfaces and a white inner layer.
 4. Material: Valve manufacturer's standard solid plastic.
 5. Size: 1-1/2 inches (40 mm) in diameter, unless otherwise indicated.
 6. Shape: As indicated for each piping system.
- M. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.
- N. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
 1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
 2. Thickness: [1/16 inch] [1/8 inch], unless otherwise indicated.
 3. Thickness: 1/16 inch, for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
 4. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.
- O. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:
 1. Green: Cooling equipment and components.
 2. Yellow: Heating equipment and components.

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3. Brown: Energy reclamation equipment and components.
 4. Blue: Equipment and components that do not meet criteria above.
 5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
 6. Terminology: Match schedules as closely as possible. Include the following:
 - a. Name and plan number.
 - b. Equipment service.
 - c. Design capacity.
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
 7. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
- P. Plasticized Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with mat finish suitable for writing.
1. Size: 3-1/4 by 5-5/8 inches.
 2. Fasteners: Brass grommets and wire.
 3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
- Q. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in piped utility identification with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of piped utility systems and equipment.
1. Multiple Systems: Identify individual system number and service if multiple systems of same name are indicated.
- 2.8 GROUT
- A. Description: ASTM C 1107, Grade B, non-shrink and non-metallic, 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 , 28-day compressive strength.
 3. Packaging: Premixed and factory packaged.

PART 3 EXECUTION

3.1 PIPED UTILITY DEMOLITION

- A. Refer to Division 01 7329 Section "Cutting and Patching" and Division 02 4116 "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove piped utility systems, equipment, and components indicated to be removed.

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1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make operational.
 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.
- 3.2 PIPING SYSTEMS REQUIREMENTS
- A. Install piping according to the following requirements and Division 33 0500 Sections “Common Work Results for Utilities” for 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 indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping to permit valve servicing.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends and solidly supported to prevent deflection.
- G. Install fittings for changes in direction and branch connections.
- H. Select system components with pressure rating equal to or greater than system operating pressure.
- I. Permanent sleeves are not required for holes formed by removable PE sleeves.
- J. Install sleeves for pipes passing through concrete and masonry walls 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 equipment areas or other wet areas 2 inches above finished floor level.
 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - a. PVC or Steel Pipe Sleeves: For pipes smaller than NPS 6.
 - b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
- K. Verify final equipment locations for roughing-in.

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- L. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. 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 leadfree solder alloy complying with ASTM B 32.
- D. 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.
- E. 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 inside diameter.
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 5. PVC Non pressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Non pressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- I. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- J. Plastic Non pressure Piping Gasketed Joints: Join according to ASTM D 3212.

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- K. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.
 - L. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- 3.4 PIPING CONNECTIONS
- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 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.
- 3.5 EQUIPMENT INSTALLATION – COMMON REQUIREMENTS
- A. Install equipment level and plumb, unless otherwise noted.
 - B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.
 - C. Install equipment to allow right of way to piping systems installed at required slope.
- 3.6 PAINTING
- A. Painting of piped utility systems, equipment, and components is specified in Division 09 Section "Painting."
 - B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.
- 3.7 IDENTIFICATION
- A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.
 - 1. Stenciled Markers: According to ASME A13.1.
 - 2. Plastic markers, with application systems. Install on insulation segment if required for hot non insulated piping.
 - 3. Locate pipe markers on exposed piping according to the following:
 - a. Near each valve and control device.
 - b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
 - c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.

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- d. At manholes and similar access points that permit view of concealed piping.
 - e. Near major equipment items and other points of origination and termination.
 - B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.
 - 1. Lettering Size: Minimum 1/4 inch high for name of unit if viewing distance is less than 24 inches, 1/2 inch high for distances up to 72 inches, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
 - 2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
 - C. Adjusting: Relocate identifying devices that become visually blocked by other work.
- 3.8 CONCRETE BASES
- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 6 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Unless otherwise indicated, use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete".
 - B. Provide concrete equipment bases at all mechanical and electrical equipment. Coordinate with affected trades.
- 3.9 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 piped utility materials and equipment.
 - C. Field Welding: Comply with AWS D1.1.
- 3.10 GROUTING
- A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.

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- 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.

END OF SECTION

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SECTION 334100

STORM SEWERS, UNDERDRAINS, AND DRAINAGE STRUCTURES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section. Where these specifications differ from the local or City's standard detail sheets, the detail sheets shall govern. All storm sewer materials and installation procedures shall conform to DWSD requirements.

1.2 SUMMARY

- A. The work under this Section includes, but is not necessarily limited to, the furnishing and installation of all storm sewers, underdrains and drainage structures and leads and connections as indicated on the Drawings, herein specified and as necessary for the proper and complete performance of this Work for foundations and under slab areas.
 - 1. Storm Sewer Pipe
 - 2. Culverts
 - 3. Perforated Underdrain Pipe
 - 4. Castings
 - 5. Manhole Sections and Steps
 - 6. Catch Basin
 - 7. Brick and Concrete Block Masonry
- B. Related Sections may include, but not be limited to, the following:
 - 1. Division 22 Sections "Plumbing" for Mechanical Section "Storm Drainage Piping" for interior building systems including conductors, horizontal branches and connections to roof to deck drain.
 - 2. Division 31 2000 Section "Earth Moving" for excavation and backfill.
 - 3. Division 33 4600 Section "Subdrainage" for Foundation Drainage Systems."

1.3 QUALITY ASSURANCE

- A. Use only personnel completely trained and experienced in installation of the materials.
- B. Compliance to DWSD Codes and all other agencies having jurisdiction shall govern material and installation procedures.

1.4 SUBMITTALS

- A. Shop Drawings: Shop drawing submittals are not required for storm sewer materials. Contractor is expected to conform to the plans, specifications, and details for this work. Submit material certificates in lieu of shop drawings. Material certificates shall be signed

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by manufacturer and contractor certifying that each material item complies with or exceeds requirements. Shop drawings will not be reviewed.

1.5 PRODUCT HANDLING

- A. Protection: Use all means necessary to protect the materials before, during and after installation.
- B. Replacements: In the event of damage, immediately make all necessary repairs and replacements acceptable to the Engineer and at no additional cost to the Owner

PART 2 PRODUCTS

2.1 STORM SEWER PIPE

- A. General: Storm sewer pipe material shall be as indicated on the plans. If indicated on the plans, pipe materials shall conform to the following requirements.
- B. Reinforced Concrete Pipe
 - 1. Reinforced concrete pipe shall conform to ASTM C-76.72A, Type III & Type IV.
 - 2. Joints shall be premium rubber joint as acceptable to the Engineer unless otherwise specified on the drawings.
- C. Corrugated Polyethylene Tubing (CPT)
 - 1. Corrugated Polyethylene Tubing (CPT) shall conform to ASTM F405 and shall be perforated with sock where indicated on the plans.
 - 2. Joints shall be secured with a factory made snap-on or screen-on coupler for 4" and 6" diameter. Joints for 8" diameter and larger shall be a factory-made coupler ties, bolts or screws on.
- D. Smooth Lined Corrugated Polyethylene Pipe (SLCPP)
 - 1. Corrugated polyethylene pipe shall have a smooth interior wall, Manning's "n" of 0.012 or better and shall conform to AASHTO M294.
 - 2. Joints shall be secured with a tied or bolted polyethylene coupler or shall be a factory-made coupler which can be screw turned on to the end corrugations.
 - 3. Corrugated polyethylene pipe shall be Advanced Drainage Systems N-12, Hancor HiQ or accepted equal.
- E. Corrugated Steel Pipe and Fittings: ASTM A 760/A 760M, Type I with fittings of similar form and construction as pipe.
 - 1. Special-Joint Bands: Corrugated steel with O-ring seals.
 - 2. Coating: Zinc.
- F. Corrugated Aluminum Pipe and Fittings: ASTM B 745/B 745M, Type I with fittings of similar form and construction as pipe.
 - 1. Special-Joint Bands: Corrugated steel with O-ring seals.

2.2 CULVERTS

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- A. Culverts shall be 16 gauge corrugated galvanized steel pipe unless otherwise indicated on drawings.
- B. Joints shall be restrained by Hugger bands or accepted equal.
- C. Metal end sections shall conform to current MDOT Standard Specifications for Highway Construction

2.3 PERFORATED UNDERDRAIN PIPE (PE or CPP)

- A. General
 - 1. Perforated underdrain pipe shall be perforated, corrugated polyethylene pipe.
 - 2. The pipe shall have a factory installed geotextile pipe wrap.
 - 3. Perforation shall meet the requirements of AASHTO M 278.
- B. Polyethylene Pipe (PE): Polyethylene pipe and fittings shall be standard strength and conform to ASTM F 405 and AASHTO M 252.
- C. Polyvinyl Chloride Pipe (PVC): Polyvinyl Chloride pipe and fitting shall be standard strength and conform to ASTM F 800.
- D. Geotextile Pipe Wrap: Geotextile pipe wrap shall weigh at least 3.5 ounces per square yard and shall conform to AASHTO M 288. It shall not be ripped or torn. The minimum tensile strength shall be 100 pounds

2.4 CASTINGS

- A. General: All castings shall be of cast iron, conforming to ASTM A 48 unless otherwise indicated. Conform to details and notes indicated on the plans. Where details or notes are not indicated, conform with the following requirements.
- B. Manhole frames and covers: Material shall be MDOT Type A with perforated covers.
- C. Catch basins and inlet castings: Catch basin and inlet castings shall be MDOT Type K when located in curbs and gutter, MDOT Type E in non-paved locations, and MDOT Type A when located in paved areas.

2.5 MANHOLE SECTIONS

- A. Manhole walls
 - 1. Standard manhole walls shall be Precast concrete units conforming to ASTM C 478, or be concrete block masonry.
- B. Manhole bases: Manhole bases shall be precast concrete units of the dimensions indicated on the Drawings.

2.6 MANHOLE STEPS

- A. Manhole steps shall be of cast iron conforming to ASTM A 48 or equal and shall meet pertinent safety rules and regulations.

2.7 CATCH BASINS

- A. Construct catch basins of brick, block, masonry, or Precast units. Precast concrete catch basin units, if used, shall have reinforcing steel conforming to ASTM C 76 II, Wall B.

Storm Sewers, Underdrains, and Drainage Structures

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2.8 INLETS

- A. Construct inlets of brick, block, masonry, or Precast units. Precast inlet units, if used, shall have reinforcing steel conforming to ASTM C 76 II, Wall B.

2.9 CLEANOUTS

- A. Gray-Iron Cleanouts: Use in pavement areas. ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
 - 1. Top-Loading Classification: Heavy duty.
 - 2. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.
- B. PVC Cleanouts: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.10 MORTAR

- A. Mortar for brick masonry or plastering manholes shall be made of one part Portland cement to two parts sand, and materials and mixing shall correspond, in general, to Division 04 2000 Section "Unit Masonry."

2.11 BRICK

- A. Brick Work shall meet the requirements of Medium Brick of ASTM C 13.

2.12 CONCRETE BLOCK MASONRY

- A. Concrete block masonry shall conform to ASTM C 139.

2.13 OTHER MATERIALS

- A. All other materials not specifically described but required for a complete and proper installation of the work of this Section, shall be new, first quality of their respective kinds, and as selected by the Contractor subject to review by the Engineer.

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

- A. Inspection
 - 1. Verify that all work under this Section may be installed in accordance with all pertinent codes and regulations, the original design and the reference standards.
 - 2. All materials shall be inspected immediately before installation, and if found defective, immediately removed from the site.
- B. Discrepancies
 - 1. In the event of discrepancy, immediately notify the Engineer.
 - 2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

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3.2 EARTHWORK

- A. All earthwork required for the performance of the work of this Section shall be installed in accordance with Division 31 2000 Section "Earth Moving."

3.3 INSTALLATION

- A. General: Install all pipe and fittings in strict accordance with the manufacturer's recommendations as acceptable to the Engineer and other authorities having jurisdiction.
- B. B. Handling
 - 1. Distribute pipe and materials at the site as required, care to prevent damage to the pipe and materials.
 - 2. Use proper tools and implements for safely handling and installing the pipe and other materials.
 - 3. Protect the pipe and other materials from falling to the ground or into the trench.
 - 4. Protect distributed pipe and materials from the public and passing vehicles.
- C. Laying pipe
 - 1. Lay all pipe true to line and grade with pipe ends abutting each other and the bell end facing the direction of laying.
 - 2. Use laser alignment equipment to establish and maintain proper line and grade, unless otherwise directed.
 - 3. Correct any deviation from line and grade at no additional cost to the Owner.
 - 4. Protect workers at all times from cave-in and other hazardous conditions.
- D. Joints: Inspect each joint immediately after being completed and, if defective, shall be corrected before any more pipe is laid.
- E. Concrete encasement
 - 1. Place concrete encasements in locations and to the form and dimensions indicated.
 - 2. Concrete for encasements shall be Class SE with that below the pipe dry mixed.
 - 3. Take particular care to place the concrete under the pipe, and lay pipe in fresh concrete so that a complete support of the pipe will be made. Encasement at the sides and top may be placed after the concrete under this pipe has been set.
- F. Manholes
 - 1. Construct manholes as indicated on the Drawings and Specifications.
 - 2. Take special care in forming the channels in the concrete bottom and use wooden templates or half sewer pipe for this work.
 - 3. Plaster masonry work and castings as indicated on the Drawings.
 - 4. In precast concrete manholes, the bottom section shall have cast openings of sufficient size to receive the sewer pipe. If such openings are not provided, the bottom portion may be constructed of masonry work from the concrete base to at least 6" above the top of the largest pipe entering the manhole and Precast sections placed from the masonry to the desired top elevation.

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5. All the annular space between the sewer pipe and the opening in the manhole section shall be filled with brick and/or masonry to provide a waterproof seal.
 6. Place the manhole casting on a minimum of 3 courses of masonry brick and a maximum of 5 courses of manhole brick. Install bricks radially. Precast concrete adjusting rings may be used in place of brick.
 7. Mortar joints have to be smooth tooled joints.
- G. Catch basins and inlets
1. Construct catch basins and inlets as indicated on the Drawings and Specifications.
 2. Place catch basin and inlet castings on a minimum of 3 courses of manhole brick and a maximum of 5 courses of manhole brick. Install brick radially. Precast concrete adjusting rings may be used in place of brick.
- H. Trench bracing: Install trench bracing in accordance with safety and other pertinent rules and regulations, and Division 31 Section "Earth Moving."
- I. Erosion control and sedimentation: Contractor to provide erosion control to minimize introduction of sedimentation into the system.
- 3.4 CLEANING
- A. Prior to acceptance of storm sewers, underdrains, manholes and drainage structures, thoroughly clean those structures and remove all dirt and debris of whatever nature from inside sewer pipes, manholes and the like, and leave the site in a neat and clean condition.

END OF SECTION

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SECTION 334613

FOUNDATION DRAINAGE SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. Work required for this section includes foundation drainage system including supplementary items necessary to complete their installation.
- B. Related Requirements:
 - 1. Refer to Plumbing Consultant Documents for foundation and underfloor drainage systems.

1.2 ACTION SUBMITTALS

- A. Product Data: Manufacturers technical literature for each product and system indicated.
 - 1. Include manufacturer's specifications for materials, finishes, construction details, installation instructions, and recommendations for maintenance.
- B. Shop Drawings: Show details of fabrication and installation, including plans, elevations, sections, details of components and attachments to other work. Distinguish between shop and field-assembled work.
 - 1. Show details and installation drawings for interface with drainage pipe system.
- C. Samples:
 - 1. Geotextile Filter Fabric: Two 12 inch squares.
 - 2. Perforated drain pipe:
 - a. Pipe: 12" inch long piece.
 - b. Fittings: One of each.

1.3 INFORMATIONAL SUBMITTALS

- A. Field Quality Control Reports: Written report of testing and inspection required by "Field Quality Control".

1.4 COORDINATION

- A. Coordinate and schedule sequencing with materials trades for concrete walls, foundations, concrete finishing, waterproofing, excavation, and backfilling.

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PART 2 - PRODUCTS

2.1 MATERIALS

- A. Molded-Sheet Drainage Panels: Refer to Division 07 waterproofing section.
- B. Filter Fabric: Woven or nonwoven geotextile filter fabric of polypropylene or polyester fibers, or combination of both. Flow rates range from 110 to 330 gpm per sq. ft. when tested according to ASTM D 4491.
- C. Perforated Drainage Pipe: ASTM D 2729 Polyvinyl Chloride nominal 4 inch, bell-and-spigot pipe including fittings, cleanouts, etc.
 - 1. Refer to Plumbing Consultant Documents for perforated drainage pipe.
- D. Impervious Fill: Clay, gravel and sand mixture.
- E. Drainage Fill: Washed, evenly graded mixture of crushed stone, or crushed or uncrushed gravel, ASTM D 448, coarse aggregate, Size 57, with 100 percent passing 1-1/2 inch sieve and not more than 5 percent passing No. 8 sieve.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Acceptance of Surfaces and Conditions: Examine substrates to receive products and systems and associated work for compliance with requirements and other conditions affecting performance. Proceed only when unsatisfactory conditions have been corrected in a manner complying with Contract Documents. Starting work within a particular area will be construed as acceptance of surface conditions.

3.2 INSTALLATION, GENERAL

- A. Installation Quality Standards: In addition to standards listed elsewhere, perform Work according to following, unless otherwise specified:
 - 1. Respective manufacturer/fabricators written installation instructions.
 - 2. Accepted submittals.
 - 3. Contract Documents.

3.3 PREPARATION

- A. General: Comply with manufacturers instructions, recommendations, and specifications for cleaning and surface preparation. Surfaces shall have no defects, contaminants, or errors which would result in poor or potentially defective installation or would cause latent defects in Work.

3.4 INSTALLATION, FOUNDATION DRAINAGE SYSTEM

- A. Molded-Sheet Drainage Panels: Refer to Division 07 waterproofing section.

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B. Bottom Impervious Fill:

1. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footings have been cured and forms removed.
2. Place and compact impervious fill not less than 6 inches deep and 12 inches wide.

C. Filter Fabric:

1. Cut fabric roll to proper width prior to installation.
2. Include sufficient width to conform to trench perimeter and for minimum six inch top overlap.
3. Lap upstream roll over downstream roll minimum of two feet, to form shingled effect.
4. Ensure fabric continuity as fabric conforms to excavation surface during drainage fill placement and compaction.
5. Following drainage fill placement, fold fabric over aggregate to form longitudinal lap.
6. Place backfill soil over lap at sufficient intervals to maintain lap during subsequent backfilling.
7. Exercise care during fabric installation to prevent natural or fill soils from intermixing with drainage aggregate.

D. Drainage Fill:

1. Place supporting layer of drainage fill over compacted subgrade to compacted depth of not less than 4 inches.
2. After installing drainage piping, add drainage fill to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
3. After satisfactory testing, cover piping to width of at least 6 inches on side away from footing and above top of pipe at least 12 inches.
4. Place drainage fill in layers not exceeding 3 inches in loose depth; compact each layer placed.

E. Drain Pipe: Comply with ASTM D 2321 and as follows:

1. Excavate to proper depths, profiles and lines required for proper drainage.
2. Provide minimum slope of 1 percent (1:100) unless otherwise indicated. Slope to drain.
3. Lay drain pipe solidly bedded in filtering material with bells facing upslope and spigot end inserted fully into adjacent bell.
4. Provide full bearing for each pipe section throughout its length to true grades and alignment, and continuous slope in direction of flow.
5. Lay perforated pipe with perforations down and joints tightly closed in accordance with pipe manufacturer's recommendations.
6. Provide fittings and couplings as required.
7. Joint PVC pipe and fittings according to ASTM D 3034 with elastomeric seal gaskets according to ASTM D 2321.
8. Joint perforated, PVC pipe and fittings according to ASTM D 2729, with loose, bell-and spigot joints.
9. Provide riser extensions and clean-outs at grade at approximately 100 feet on center. Locate at beginning of pipe run and changes in direction.
10. Set top of clean-outs 1 inch above grade and secure in 12 inch square by 4 inch deep concrete anchor.
11. Extend piping and connect to building storm drainage system or building sump pumps.

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3.5 FIELD QUALITY CONTROL

- A. Testing: After installing drainage fill to top of pipe, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

3.6 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION