

PROJECT MANUAL

Surgery Center of Lee's Summit

1950 SE Shenandoah Drive
Lee's Summit, MO 64063

VOLUME 3 OF 4 **(DIVISIONS 21 thru 33)**

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Project No. 3-22030

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**SECTION 21 05 00
COMMON WORK RESULTS FOR FIRE SUPPRESSION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe, fittings, sleeves, escutcheons, seals, and connections for sprinkler systems.

1.02 REFERENCE STANDARDS

- A. ASME A112.18.1 - Plumbing Supply Fittings 2018.
- B. ASME BPVC-IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators - Welding Brazing and Fusing Qualifications 2019.
- C. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250 2015.
- D. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- E. ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250 2021.
- F. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard 2020.
- G. ASME B16.9 - Factory-Made Wrought Buttwelding Fittings 2018.
- H. ASME B16.11 - Forged Fittings, Socket-welding and Threaded 2016 (Errata 2017).
- I. ASME B16.25 - Buttwelding Ends 2017.
- J. ASME B36.10M - Welded and Seamless Wrought Steel Pipe 2018.
- K. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings 1999, with Editorial Revision (2022).
- L. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- M. ASTM A135/A135M - Standard Specification for Electric-Resistance-Welded Steel Pipe 2021.
- N. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2022.
- O. ASTM A536 - Standard Specification for Ductile Iron Castings 1984, with Editorial Revision (2019).
- P. ASTM A795/A795M - Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use 2021.
- Q. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- R. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems 2013a (Reapproved 2017).
- S. AWS D1.1/D1.1M - Structural Welding Code - Steel 2020.
- T. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems 2018.
- U. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings 2012.
- V. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings 2017.
- W. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast 2017, with Errata (2018).
- X. AWWA C606 - Grooved and Shouldered Joints 2015.
- Y. FM (AG) - FM Approval Guide current edition.
- Z. NFPA 13 - Standard for the Installation of Sprinkler Systems Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- AA. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems 2016.
- BB. UL (DIR) - Online Certifications Directory Current Edition.

1.03 SUBMITTALS

- A. Product Data: Provide manufacturers catalogue information. Indicate valve data and ratings.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Project Record Documents: Record actual locations of components and tag numbering.
- D. Submit a specification compliance review where indicated in individual sections.
 - 1. At each paragraph of the specification indicate in the left hand margin if the paragraph "NA" not applicable, "C" complies or "E" exception. Explain fully any exceptions to the paragraphs. Shop drawings and product data will not be reviewed without submitting the specification compliance review.
- E. Operation and Maintenance Data: Include installation instructions and spare parts lists.

1.04 QUALITY ASSURANCE

- A. Comply with FM (AG) and UL (DIR) requirements.
- B. Valves: Bear FM (AG) and UL (DIR) product listing label or marking. Provide manufacturer's name and pressure rating marked on valve body.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers, with labeling in place.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

1.06 WARRANTY

- A. Warrant the installed fire suppression systems are fully coordinated, complete, and properly functioning as outlined in the Construction Documents for a period of one year after date of substantial completion.
- B. Specific equipment may require a longer warranty. Warrant equipment for longer period of time listed in the contract documents.
- C. Repair or replace at no cost to the owner any items which prove defective during the warranty period.
- D. Contractor is responsible to replace any equipment or portion of that equipment whose manufacturer's warranty is based on "time from shipment" which has expired prior to the end of the project's base warranty period or any specified special warranty periods(s). Extended manufacturer's warranties may be utilized to provide coverage for the required warranty periods(s) and shall be included in the contractor's bid.
- E. The contractor agrees not to void or allow subcontractors to void any warranty regarding products installed as a part of this project.

1.07 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

- A. If questions arise during the bidding process regarding the meaning of any portion of the contract document, the prospective bidder shall submit the questions to the Architect/Engineer for clarification prior to date of last addendum.
- B. Interpretation or clarification of the contract documents will be published by addenda.
- C. Verbal interpretation or explanations not issued in the addenda shall not be considered part of the contract documents.
- D. Where conflicts exist between within the contract documents or between the contract documents and adopted codes the contractor shall bid the more expensive method and products.
- E. The Architect/Engineer shall be the sole judge regarding interpretations of conflicts.
- F. The contractor shall confirm their equipment suppliers have thoroughly reviewed all portions of the contract documents and reported any ambiguities, discrepancies, errors, inconsistencies or

omissions to the Architect in writing prior to the last addendum date. Any items not identified shall be bid as the most expensive option.

1.08 CONTRACT DOCUMENT DISCREPANCIES

- A. Thoroughly review all portions of the Contract Documents to fully coordinate fire suppression items, including their proper installation, which will be utilized on this project. Provide costs for incidental work and materials needed to complete the installation based on field conditions.
- B. If any conflicts or ambiguities appear in the contract documents, request clarification from the Architect/Engineer before proceeding with work.
- C. If the contractor fails to report or request clarification of contract documents discrepancies or ambiguities, no excuse will be entertained for failure to preform work to the satisfaction of the Architect/Engineer.

1.09 PERMITS AND INSPECTIONS

- A. The contractor shall obtain and pay for all permits, fees, and licenses required for the construction and acceptance of the fire suppression system by the Engineer and authority having jurisdiction.
- B. The contractor shall call for, obtain and pay for any and all inspections and re-inspections required for the work indicated in the contract documents.
- C. Contractor shall coordinate with the local utility and follow local rules and regulations. Contractor shall pay for fees and services used prior to final completion..
- D. If a portion of the electrical system does not pass tests or inspections, make required corrections and arrange for re-inspection.
- E. Contact AHJs and coordinate the requirements, timing, and and completion of all required inspections.

1.10 OBSERVATION OF WORK

- A. The Engineer's site visits will consist of visual observations of the construction, and the equipment and materials used therein, to permit the Engineer to render their professional opinion as to the Contractor's conformance to the intent of the Bid Documents. Given the inherent limitations of such inspections, they shall not be relied upon by any party as acceptance of the work, nor shall they relieve any party from fulfillment of customary and contractual responsibilities and obligations.
- B. Although Engineer may confer with the Contractor regarding interpretation of plans and specifications, such assistance shall not relieve Contractor of any responsibility for the work.
- C. The fact that the Engineer has failed to observe faulty work, or work done which is not in accordance with the drawings and specifications, shall not relieve the Contractor from responsibility for correcting such work without additional compensation.
- D. Prior to the engineer's final construction observation (final punch visit) the contractor shall provide the engineer a half sized set of construction documents with devices and equipment highlighted to show device/equipment has been installed and is complete. Items not highlighted shall be noted as to what work still remains to be completed.

1.11 COORDINATION

- A. Coordinate arrangement, mounting and support of fire suppression equipment;
- B. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
- C. To provide for ease of disconnecting the equipment with minimum interference to other installations.
- D. To allow right of way for piping installed at required slope.
- E. To allow proper access to all equipment requiring access.
- F. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the fire suppression

installations that follow.

- G. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- H. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- I. Coordinate fire suppression connections to components furnished by utility companies.
- J. Provide offsets and elevation changes in fire suppression system components as required to complete the layout and coordination process.
- K. Be thoroughly familiar with all portions of the Contract Documents to insure fire suppression equipment, material, and work are fully coordinated with each contractor's equipment, material, and work at this site.

1.12 STRUCTURAL COORDINATION

- A. In cases where the Contractor determines that superimposed loads such as suspended or floor mounted equipment exist which exceed design loads indicated on structural documents, The Contractor shall submit load data to Architect/Engineer for review prior to proceeding with work.
- B. Connections of systems designed by Contractor's engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

PART 2 PRODUCTS

2.01 FIRE PROTECTION SYSTEMS

- A. Sprinkler Systems: Comply with NFPA 13.
- B. Welding Materials and Procedures: Comply with ASME BPVC-IX.

2.02 BURIED PIPING

- A. Steel Pipe: ASTM A53/A53M Schedule 40, ASTM A135/A135M Schedule 10, ASTM A795/A795M Standard Weight, or ASME B36.10M Schedule 40, black, with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.
 - 1. Steel Fittings: ASME B16.9, wrought steel, butt welded, ASME B16.25, butt weld ends, ASTM A234/A234M, wrought carbon steel or alloy steel, ASME B16.5, steel flanges and fittings, or ASME B16.11, forged steel socket welded and threaded; with double layer, half-lapped polyethylene tape.
 - 2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings.
 - 3. Joints: Welded in accordance with AWS D1.1/D1.1M.
- B. 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.

2.03 ABOVE GROUND PIPING

- A. Steel Pipe: black.
 - 1. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings and ASME B16.4, threaded fittings.
 - 2. Malleable Iron Fittings: ASME B16.3, threaded fittings and ASTM A47/A47M.
 - 3. 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.
- B. Ductile Iron Pipe: AWWA C151/A21.51.
 - 1. Fittings: AWWA C110/A21.10, standard thickness.

2. Joints: AWWA C111/A21.11, SBR or vulcanized styrene butadiene rubber gasket.

2.04 PIPE SLEEVES

- A. Vertical Piping:
 1. Sleeve Length: 1 inch above finished floor.
 2. Provide sealant for watertight joint.
 3. Blocked Out Floor Openings: Provide 1-1/2 inch angle set in silicon adhesive around opening.
 4. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- B. 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 Quarry Tile, Terrazzo, or Ceramic Tile Floors:
 1. Brass pipe.
 2. Connect sleeve with floor plate.
- E. 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.
- F. Pipe Passing Through Mechanical, Laundry, and Animal Room Floors above Basement:
 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 2. Connect sleeve with floor plate except in mechanical rooms.
- G. Not required for wall hydrants for fire department connections or in drywall construction.
- H. Penetrations in concrete beam flanges are permitted but are prohibited through ribs or beams without prior approval from the Architect.
- I. Clearances:
 1. Provide allowance for insulated piping.
 2. Wall, Floor, Floor, Partitions, and Beam Flanges: 1 inch greater than external; pipe diameter.
 3. Rated Openings: Caulked tight with fire stopping material complying with ASTM E814 in accordance with Section 07 84 00 to prevent the spread of fire, smoke, and gases.

2.05 MANUFACTURED SLEEVE-SEAL SYSTEMS

- A. Modular/Mechanical Seal:
 1. Synthetic rubber interlocking links continuously fill annular space between pipe and wall/casing opening.
 2. Provide watertight seal between pipe and wall/casing opening.
 3. Elastomer element size and material in accordance with manufacturer's recommendations.
 4. Glass reinforced plastic pressure end plates.

2.06 FIRE-RATED ENCLOSURES

- A. Provide as required to preserve fire resistance rating of building elements.

2.07 ESCUTCHEONS

- A. Material:
 1. Fabricate from nonferrous metal.
 2. Chrome-plated.
 3. Metals and Finish: Comply with ASME A112.18.1.

- B. 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.

2.08 PIPE HANGERS AND SUPPORTS

- A. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Malleable iron, adjustable swivel, split ring.
- B. Hangers for Pipe Sizes 2 inches and Over: Carbon steel, adjustable, clevis.
- C. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- D. Wall Support for Pipe Sizes to 3 inches: Cast iron hook.
- E. Wall Support for Pipe Sizes 4 inches and Over: Welded steel bracket and wrought steel clamp.
- F. Vertical Support: Steel riser clamp.
- G. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.

2.09 MECHANICAL COUPLINGS

- A. Rigid Mechanical Couplings for Grooved Joints:
 - 1. Dimensions and Testing: Comply with AWWA C606.
 - 2. Minimum Working Pressure: 300 psig.
 - 3. Housing Material: Fabricate of ductile iron complying with ASTM A536.
 - 4. Housing Coating: Factory applied orange enamel.
 - 5. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F to 230 degrees F.
 - 6. Bolts and Nuts: Hot dipped galvanized or zinc electroplated steel.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- 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.
 - 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 recessed into and grouted flush with slab.
- H. Pipe Hangers and Supports:

1. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 2. Place hangers within 12 inches of each horizontal elbow.
 3. Use hangers with 1-1/2 inch 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.
 6. Provide copper plated hangers and supports for copper piping.
- 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.
- K. 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 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 Division 07 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.
- L. 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.
- M. 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. Use chrome plated escutcheons in occupied spaces and to conceal openings in construction.
- N. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.03 CLEANING

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

END OF SECTION

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SECTION 21 05 23
GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 GENERAL

1.01 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. NRS gate valves.
- F. Indicator posts.
- G. Trim and drain valves.

1.02 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 2015.
- C. ASME B31.9 - Building Services Piping 2020.
- D. ASME BPVC-IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators - Welding Brazing and Fusing Qualifications 2019.
- E. AWWA C606 - Grooved and Shouldered Joints 2015.
- F. FM (AG) - FM Approval Guide current edition.
- G. NFPA 13 - Standard for the Installation of Sprinkler Systems Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL (DIR) - Online Certifications Directory Current Edition.
- I. UL 262 - Gate Valves for Fire-Protection Service Current Edition, Including All Revisions.
- J. UL 312 - Check Valves for Fire-Protection Service Current Edition, Including All Revisions.
- K. UL 789 - Indicator Posts for Fire-Protection Service Current Edition, Including All Revisions.
- L. UL 1091 - Standard for Butterfly Valves for Fire-Protection Service Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01 30 00 - 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. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Obtain valves for each valve type from single manufacturer.
 - 2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.
- B. Where listed products are specified, provide products listed, classified, and labeled by FM (AG), UL (DIR), or testing firm acceptable to authorities having jurisdiction as suitable for the purpose indicated.
- C. Welding Materials and Procedures: Comply with ASME BPVC-IX.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. 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.
- C. Use the following precautions for handling:
 1. Do not use operating handles or stems as lifting or rigging points.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. UL Listed: Provide valves listed in UL (DIR) under following headings and bearing UL mark:
- B. FM Global Approved: Provide valves listed in FM (AG) Approval Guide under the following headings:
 1. Automated Sprinkler Systems:
 - a. Indicator posts.
 - b. Valves:
 - 1) Gate valves.
 - 2) Single check valves.
 - 3) Miscellaneous valves.
- C. ASME Compliance:
 1. ASME B16.1 for flanges on iron valves.
 2. ASME B1.20.1 for threads on threaded-end valves.
 3. ASME B31.9 for building services piping valves.
- D. Comply with AWWA C606 for grooved-end connections.
- E. Comply with NFPA 13 for valves.
- F. Valve Pressure Ratings: Not less than minimum pressure rating indicated or higher as required.
- G. Valve Sizes: Same as upstream piping unless otherwise indicated.

2.02 TWO-PIECE BALL VALVES WITH INDICATORS

- A. UL 1091, except with ball instead of disc and FM (AG) standard listing for indicating valves (butterfly or ball type), Class Number 1112.
- B. Description:
 1. Minimum Pressure Rating: 175 psig.
 2. Body Design: Two piece.
 3. Body Material: Forged brass or bronze.
 4. Port Size: Full or standard.
 5. Seat: PTFE.
 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 for Valves 1 NPS through 2 NPS: Threaded ends.
 11. End Connections for Valves 2-1/2 NPS: Grooved ends.

2.03 IRON BUTTERFLY VALVES WITH INDICATORS

- A. UL 1091 and FM (AG) standard listing for indicating valves (butterfly or ball type), Class Number 112.
- B. Minimum Pressure Rating: 175 psig.
- C. Body Material: Cast or ductile iron with EPDM or epoxy coating.
- D. Seat: EPDM.
- E. Stem: Stainless steel.
- F. Disc: Ductile iron, nickel plated.
- G. Actuator: Worm gear or traveling nut.
- H. Supervisory Switch: Internal or external.
- I. Body Design: Grooved-end connections.

2.04 CHECK VALVES

- A. UL 312 and FM (AG) standard listing for check valves, Class Number 1045.
- B. Minimum Pressure Rating: 175 psig.
- C. Type: Center guided check valve.
- D. Body Material: Cast iron, ductile iron.
- E. Center guided check with elastomeric seal.
- F. Hinge Spring: Stainless steel.
- G. End Connections: Flanged, grooved, or threaded.

2.05 IRON OS&Y GATE VALVES

- A. UL 262 and FM (AG) standard listing for fire-service water control valves (OS&Y and NRS-type gate valves).
- B. Minimum Pressure Rating: 175 psig.
- C. Body and Bonnet Material: Cast or ductile iron.
- D. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
- E. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
- F. Stem: Brass or bronze.
- G. Packing: Non-asbestos PTFE.
- H. Supervisory Switch: External.
- I. End Connections: Flanged.

2.06 NRS GATE VALVES

- A. UL 262 and FM (AG) standard listing for fire-service water control valves (OS&Y and NRS-type gate valves).
- B. Minimum Pressure Rating: 175 psig.
- C. Body and Bonnet Material: Cast or ductile iron.
- D. Wedge: Cast or ductile iron with elastomeric coating.
- E. Stem: Brass or bronze.
- F. Packing: Non-asbestos PTFE.
- G. Supervisory Switch: External.
- H. End Connections: Flanged.

2.07 INDICATOR POSTS

- A. UL 789 and FM (AG) standard listing for indicator posts.
- B. Type: Underground.

- C. Base Barrel Material: Cast or ductile iron.
- D. Extension Barrel for Adjustable Length Indicator Posts: Cast or ductile iron.
- E. Cap: Cast or ductile iron.
- F. Operation: Wrench.

2.08 TRIM AND DRAIN VALVES

- A. Ball Valves:
 - 1. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Design: Two piece.
 - c. Body Material: Forged brass or bronze.
 - d. Port Size: Full or standard.
 - e. Seat: PTFE.
 - f. Stem: Bronze or stainless steel.
 - g. Ball: Chrome-plated brass.
 - h. Actuator: Hand-lever.
 - i. End Connections for Valves 1 NPS through 2-1/2 NPS: Threaded ends.

PART 3 EXECUTION

3.01 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.
 - 3. Replace all defective valves with new valves.

3.02 INSTALLATION

- A. Comply with specific valve installation requirements and application in the following Sections:
- B. Install listed fire protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections.
 - 1. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in water supply connections and backflow preventer at potable water supply connections.
- D. Valves with threaded connections to have unions at equipment arranged for easy access, service, maintenance, and equipment removal without system shutdown.
- E. Valves in horizontal piping installed with stem at or above the pipe center.
- F. Position valves to allow full stem movement.
- G. Install valve tags. Comply with Section 21 05 53 requirements for valve tags, schedules, and signs on surfaces concealing valves; and the appropriate NFPA standard applying to the piping system in which valves are installed.

END OF SECTION

SECTION 21 05 53
IDENTIFICATION FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials 2017.

1.03 SUBMITTALS

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

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Automatic Controls: Tags.
- B. Control Panels: Nameplates.
- C. Instrumentation: Tags.
- D. Major Control Components: Nameplates.
- E. Piping: Tags.
- F. Pumps: Nameplates.
- G. Relays: Tags.
- H. Small-sized Equipment: Tags.
- I. Thermostats: Nameplates.
- J. Valves: Nameplates and ceiling tacks where above lay-in ceilings.

2.02 NAMEPLATES

- A. Description: Laminated three-layer plastic with engraved letters.
 - 1. Letter Color: White.
 - 2. Letter Height: 1/4 inch.
 - 3. Background Color: Black.
 - 4. Thickness: 1/8 inch.
 - 5. Plastic: Comply with ASTM D709.

2.03 TAGS

- A. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- B. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.04 PIPE MARKERS

- A. Color: Comply with ASME A13.1.

- 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. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

2.05 CEILING TACKS

- A. Description: Steel with 3/4 inch diameter color coded head.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
- F. Use tags on piping 3/4 inch diameter and smaller.
 - 1. Identify service, flow direction, and pressure.
 - 2. Install in clear view and align with axis of piping.
 - 3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
- G. Locate ceiling tacks to locate valves above T-bar type panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION

**SECTION 21 07 19
FIRE SUPPRESSION PIPING INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping insulation.

1.02 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- B. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2021.
- C. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation 2017.
- D. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation 2022a.
- E. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation 2022.
- F. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel 2008 (Reapproved 2018).
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- H. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.03 SUBMITTALS

- 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.

1.04 QUALITY ASSURANCE

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

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

2.02 GLASS FIBER

- A. Manufacturers:
 - 1. CertainTeed Corporation: www.certainteed.com/#sle.
 - 2. Johns Manville Corporation: www.jm.com/#sle.
 - 3. Knauf Insulation; Earthwool 1000 Degree Pipe Insulation: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation: www.ocbuildingspec.com/#sle.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
 - 1. K Value: ASTM C177, 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: 850 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.

- C. Insulation: ASTM C547 and ASTM C795; semi-rigid, noncombustible, end grain adhered to jacket.
 - 1. K Value: ASTM C177, 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: 650 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- D. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.

2.03 CELLULAR GLASS

- A. Manufacturers:
 - 1. Owens Corning Corporation: www.ocbuildingspec.com/#sle.
- B. Pipe and Tube Insulation: ASTM C552, Type II, Grade 6.
 - 1. K Value: 0.35 at 100 degrees F.
 - 2. Service Temperature Range: From minus 450 degrees F to 800 degrees F.
 - 3. Water Vapor Permeability: 0.005 perm inch maximum per inch.
 - 4. Water Absorption: 0.5 percent by volume, maximum.

2.04 HYDROUS CALCIUM SILICATE

- A. Manufacturers:
 - 1. Johns Manville Corporation; [____]: www.jm.com/#sle.
- B. Insulation: ASTM C533 and ASTM C795; rigid molded, asbestos free, gold color.
 - 1. K Value: ASTM C177 and ASTM C518; 0.40 at 300 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 - 2. Maximum Service Temperature: 1200 degrees F.
 - 3. Density: 15 lb/cu ft.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. 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. 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.
- F. Inserts and Shields:
 - 1. Application: Piping 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.

3. Insert Location: Between support shield and piping and under the finish jacket.
 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- G. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07 84 00.
- H. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with canvas jacket sized for finish painting.
- I. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.
- J. 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 thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.
- K. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.03 SCHEDULE

END OF SECTION

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SECTION 21 11 00
FACILITY FIRE-SUPPRESSION WATER-SERVICE PIPING

PART 2 PRODUCTS

END OF SECTION

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**SECTION 21 13 00
FIRE-SUPPRESSION SPRINKLER SYSTEMS**

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 REFERENCE STANDARDS

- A. FM (AG) - FM Approval Guide current edition.
- B. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements 2015.
- C. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements 2016.
- 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 1963 - Standard for Fire Hose Connections 2019.
- F. UL (DIR) - Online Certifications Directory Current Edition.
- G. UL 405 - Standard for Safety Fire Department Connection Devices Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. 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.
- B. Shop Drawings:
 - 1. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
 - 2. Submit shop drawings to Authorities Having Jurisdiction for approval. Submit proof of approval to Architect.
- C. Manufacturer's Certificate: Certify that system has been tested and meets or exceeds specified requirements and code requirements.
- D. 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.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Sprinklers: Type and size matching those installed, in quantity required by referenced NFPA design and installation standard.
 - 2. Sprinkler Wrenches: For each sprinkler type.
- F. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.

1.04 QUALITY ASSURANCE

- A. Comply with FM (AG) requirements.
- B. Designer Qualifications: Design system under direct supervision of a NICET Level III experienced in design of this type of work and licensed in project jurisdiction.
- C. Equipment and Components: Provide products that bear FM (AG) label or marking.
- D. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

1.05 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.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Sprinklers, Valves, and Equipment:
 - 1. Tyco Fire Protection Products: www.tyco-fire.com/#sle.
 - 2. Viking Corporation: www.vikinggroupinc.com/#sle.

2.02 SPRINKLER SYSTEM

- A. Sprinkler System: Provide coverage for entire building.
- B. Occupancy: Ordinary hazard, Group 1; comply with NFPA 13.
- C. Water Supply: Determine volume and pressure from water flow test data.
 - 1. Revise design when test data available prior to submittals.
- 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.
- G. Pipe Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
 - 1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
 - 2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
 - 3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
 - 4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.
 - 5. Concrete Adhesive Type Anchors: Complying with ICC-ES AC308.
 - 6. Other Types: As required.

2.03 SPRINKLERS

- A. Suspended Ceiling Type: Recessed pendant type with matching push on cover plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Finish: Enamel, color as selected.
 - 4. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- B. Exposed Area Type: Pendant type with guard.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Finish: Brass.
 - 4. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- C. Sidewall Type: Recessed horizontal sidewall type with matching screw on escutcheon plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Standard.
 - 3. Finish: Enamel, color as selected.
 - 4. Escutcheon Plate Finish: Chrome plated.
 - 5. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- D. Dry Sprinklers: Concealed pendant type with matching push on escutcheon plate.
 - 1. Response Type: Quick.
 - 2. Coverage Type: Extended.
 - 3. Finish: Enamel, color as selected.
 - 4. Cover Plate Finish: Chrome plated.
 - 5. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- E. Residential Sprinklers: Concealed upright type with matching push on cover plate.
 - 1. Response Type: Quick.
 - 2. Finish: Enamel, color as selected.
 - 3. Cover Plate Finish: Chrome plated.

- 4. Fusible Link: Fusible solder link type temperature rated for specific area hazard.
- F. Storage Sprinklers: Pendant type with guard.
 - 1. Response Type: Standard.
 - 2. Coverage Type: Standard.
 - 3. Finish: Chrome plated.
 - 4. Fusible Link: Glass bulb type temperature rated for specific area hazard.
- G. Guards: Finish to match sprinkler finish.
- H. Spray Nozzles: Brass with solid cone discharge, 30 degrees of arc with blow-off dust cap.
 - 1. Finish: Brass.

2.04 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.
 - 3. Replaceable internal components without removing valve from installed position.
- B. Backflow Preventer: Double check valve assembly backflow preventer with drain and OS & Y gate valve on each end.
- C. Test Connections:
 - 1. Backflow Preventer Test Connection:
 - a. Provide downstream of the backflow prevention assembly, listed hose valves with 2.5 inch National Standard male hose threads with cap and chain.
 - b. Furnish one valve for each 250 gpm of system demand or fraction thereof.
 - c. Provide permanent sign reading "Test Valve".
- D. Electric Alarm: Electrically operated red enameled gong with pressure alarm switch.
- E. 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.
- F. Fire Department Connections:
 - 1. Type: Exposed, projected wall mount made of corrosion resistant metal complying with UL 405.
 - a. Inlets: Two way, 2-1/2 inch swivel fittings, internal threaded. Thread size and inlets according to NFPA 1963 or Authority Having Jurisdiction. Brass caps with gaskets, chains, and lugs.
 - b. Finish: Chrome.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with referenced NFPA design and installation standard.
- B. Install equipment in accordance with manufacturer's instructions.
- 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 siamese connectors to allow full swing of fire department wrench handle.
- E. Locate outside alarm gong on building wall .
- F. Place pipe runs to minimize obstruction to other work.
- G. Place piping in concealed spaces above finished ceilings.
- H. 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.
- I. Flush entire piping system of foreign matter.

- J. Install guards on sprinklers .
- K. Hydrostatically test entire system.
- L. Require test be witnessed by Fire Marshal and Authority Having Jurisdiction.

3.02 INTERFACE WITH OTHER PRODUCTS

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

END OF SECTION

**SECTION 22 05 00
COMMON WORK RESULTS FOR PLUMBING**

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish all material, equipment, tools, labor, and services (including stated delegated design) as necessary & required to construct the fully coordinated, complete, and properly functioning Plumbing Systems as outlined in the Contract Documents.
- B. Section includes:
 - 1. General Requirements for Bidding and the Construction of the Plumbing Systems.
 - 2. General Requirements for Material and Equipment.
 - 3. Domestic Water Requirements.
 - 4. Sustainability Requirements.
 - 5. Escutcheons.
 - 6. Wood Stud Guards, Shields, and Stud Shoes.
 - 7. Delivery, Storage, and Handling.
 - 8. General Installation Requirements.
 - 9. Miscellaneous Construction Coordination.
 - 10. Erection of Metal Supports and Anchorage.
 - 11. Erection of Wood Supports and Anchorage.
 - 12. Damage and Touch-up Painting.
 - 13. Protection and Cleaning.
- C. Obtain and pay for all permits, fees, and licenses required for the construction and acceptance of the Plumbing Systems by all Authorities-Having-Jurisdictions (AHJs).
- D. Be responsible for all aspects of the plumbing systems' material condition, installation, operation, and maintenance until accepted by the Owner.
- E. The Engineer's definition for the plumbing portion of the Contract Documents (hereinafter referred to as the Plumbing Documents) consist of:
 - 1. All Specification Division 22 Sections.
 - 2. All Plumbing (P) Drawings.
 - 3. Plumbing portions of work shown on Mechanical/Plumbing (MP) or Mechanical/Electrical/Plumbing (MEP) Drawings.
 - 4. Other referenced portions of the Contract Documents.
 - 5. All plumbing related Addendum items.

1.02 RELATED DOCUMENTS

- A. This section, General Plumbing Requirements, is specifically applicable to all Division 22 Specification Sections.
- B. If procedures, directions, or requirements are mentioned in other portions of the Contract Documents that pertain to or interact with work shown in the Plumbing Documents, the most stringent requirement will be utilized unless directed otherwise by the Architect..
- C. Be thoroughly familiar with all portions of the Contract Documents to ensure that all plumbing equipment, material, and work are fully coordinated with all other aspects of this Project.
- D. Listing of Specification Sections and Drawings below is intended to highlight other relevant portions of the Contract Documents that apply to the Plumbing Documents, should be considered a courtesy, and does not relieve the Contractor from coordinating the Plumbing Work with all other parts of the Contract Documents.
 - 1. Division 0 "Procurement and Contracting Requirements" - General and Supplemental or Special Conditions of the Contract.
 - 2. Division 1 "General Requirements" - All sections.
 - 3. Division 3 "Concrete" - Housekeeping pads and equipment supports.
 - 4. Division 5 "Metals" - Miscellaneous metal supports not specified hereinafter in Division 22
 - 5. Division 6 "Woods, Plastics, and Composites – Fire-retardant-treated-wood blocking.

6. Division 7 "Thermal and Moisture Protection":
 - a. Joint sealant for joints between plumbing fixtures and adjoining walls, floors, and counters.
 - b. Sealing of pipe sleeves.
 - c. Flashing and sealing of roof penetrations.
 - d. Sealing of wall penetrations.
 - e. Through and membrane penetration's firestopping for fire and smoke rated assemblages.
 7. Division 8 "Openings" – Architectural access door coordination.
 8. Division 9 "Finishes" - Painting of plumbing systems for aesthetic or identification purposes.
 9. Division 11 "Equipment" - Food service, laboratory, or other equipment with plumbing connection requirements.
 10. Division 12 "Furnishings" - Casework and countertop coordination.
 11. Division 26 "Electrical" – Control-voltage electrical cables.
 12. Division 28 "Electronic Safety and Security" – Interconnection with other electronic systems.
 13. Division 31 "Earth Moving" - Excavating, trenching, and backfilling.
 14. Division 33 "Utilities" – Site utilities.
 15. Architectural Drawings :
 - a. Applicable Codes and Standards.
 - b. Reflected ceiling plans for elevations and types of ceilings.
 - c. Interior elevations for coordination with casework and wall-mounted plumbing component locations.
 - d. Location of fire/smoke rated construction and egress paths.
 - e. Location of ADA-compliant plumbing fixtures, their mounting height/installation requirements, and coordination with surrounding casework and grab bars.
 16. Civil Drawings – Site utility connections.
 17. Electrical Drawings:
 - a. Location of power connections for hard-wired, electronic plumbing faucet/flush valve's low-voltage transformers.
 - b. Power connection and requirements for plumbing equipment.
 18. Mechanical Drawings:
 - a. Natural gas requirements for mechanical equipment.
 - b. Additional information required for the connection of the equipment to the plumbing systems.
 19. Medical Equipment Documents – Additional information required for the connection of the equipment to the plumbing systems.
- E. If the above referenced related documents are not part of the Contract Documents, request a project specific copy from the Architect.

1.03 ABBREVIATIONS & DEFINITIONS

- A. AFF: Above the finished floor.
- B. AHJ: Authority having Jurisdiction.
- C. ANSI: American National Standards Institute.
- D. ASTM: ASTM International, formally known as American Society of Testing and Material.
- E. ASHRAE: American Society of Heating, Refrigeration, and Air-Conditioning Engineers.
- F. AWS: American Welding Society.
- G. Commodity items: Those plumbing components that conform to a specific standard and are identical in construction/manufacturing from one supplier to another, such as copper pipe and fittings.
- H. Component: Any pipe, fitting, valve, specialty, fixture, piece of equipment or other item required for the complete and fully functioning plumbing system.

- I. Concealed: Items which are completely hidden from view by building elements (walls, ceilings, floors, etc.) under normal conditions from any angle or point-of-view to building occupants or people outside the building.
- J. Conditioned: Interior spaces that are heated and cooled providing some level of humidity control.
- K. CPS: Copper pipe size.
- L. CWP: Cold working pressure.
- M. DZR: De-zincification resistant. DZR shall be defined as a copper alloy that contains no more than 15 percent zinc and contains additional elements that deter the selective leaching of zinc from the alloy.
- N. Exposed: Items which are visible under normal conditions from any angle or point-of-view to building occupants or people outside the building.
- O. Exterior: Areas or items located outside, subject to any portion of the ambient weather conditions, and unprotected by the building's complete thermal and moisture barriers.
- P. Finished Spaces: Spaces that are accessible to building occupants at some time except those spaces such as mechanical/electrical/elevator equipment rooms, janitor closets, furred spaces, pipe and duct shafts, unconditioned spaces immediately below the roof, void spaces above ceilings, crawlspaces, and tunnels.
- Q. g/l: Grams per liter.
- R. inches wg: inches water gage pressure.
- S. Interior: Area or items located inside and completely protected by the building's thermal and moisture barriers.
- T. IPS: Iron pipe size.
- U. Max: Maximum.
- V. Means of Mechanical Disconnection: Providing a way of disconnection that can be reconnected utilizing only the original parts and does not require the destruction of any part of the original connection. Unions, screw fittings, and flanges for piping are means of mechanical disconnection. Soldering, welding, and gluing are not considered types of mechanical disconnection.
- W. Min: Minimum.
- X. MPT: Male pipe thread.
- Y. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.
- Z. NFPA: National Fire Protection Association.
- AA. NPS: Nominal pipe size.
- BB. NPT: National Pipe Thread Taper.
- CC. NRTL: Nationally Recognized Testing Laboratory as designated by OSHA.
- DD. NSF: National Sanitation Foundation.
- EE. OSHA: United States' Occupational Safety and Health Administration.
- FF. Pipe: A rigid conduit used to convey fluid or gas.
- GG. Piping: Refers to both pipe and tubing.
- HH. Private Spaces: Those spaces that are not available for all occupants to use.
- II. psig: pounds per square inch, gauge pressure.
- JJ. Public Spaces: Those spaces that are available for all or most occupants to use.
- KK. Tempered: Interior spaces that are heated only with no level of humidity control.
- LL. Tubing: A flexible conduit used to convey fluid or gas.
- MM. VOC: Volatile organic compounds.

NN. WOG: Water, Oil, Gas.

1.04 CODES, ORDINANCES, AND STANDARDS

- A. Refer to the Architectural Code Review portion of the Contract Documents for the specific Plumbing Code(s) under which the Project was designed.
- B. All aspects of the applicable Code(s) are not specifically stated in the Plumbing Documents but are required for final installation.
- C. All references to industry standards (Example: ASTM, CISPI, MSS) in these Specifications refer to the most current edition of that standard unless the Plumbing Code in force references or the AHJ publically requires a specific edition.

1.05 INTENT OF THE PLUMBING DOCUMENTS

- A. Manufacturer and model numbers are given as a basis of design. Stated basic model numbers may not utilize all the manufacturer's extended model number that outlines all options required.
- B. The Plumbing Documents are not complete construction documents and are not intended for final system installation.
- C. Because of their small scale and variations of different manufacturers' equipment; the plumbing drawings are diagrammatic, cannot be rigid in specific details for the final installation of the systems, and should not be scaled.
- D. Routing of piping on the floor plans is for the clarity of the drawings, may not show exact locations, may not show all required offsets/transitions/spacing, and must be field coordinated.
- E. General location of equipment, fixtures, and specialties are indicated but may not show all details required for the final installation.
- F. Details and diagrams are provided to indicate minimum installation requirements and may require some modification to accommodate individual pieces of equipment or systems .
- G. When the Plumbing Documents conflict with the manufacturer's recommendations for the installed/connected equipment that would adversely affect its operation or useful life, make such adjustments that are required to ensure that all equipment is installed/connected for the safe and proper operation of the equipment and systems served.

1.06 REVIEW, INTERPRETATION, & CORRECTION OF THE PLUMBING DOCUMENTS

- A. Thoroughly review all portions of the Contract Documents to fully coordinate all plumbing items, including their proper installation, which will be utilized on this Project.
- B. No one portion of the Contract Documents takes precedent over another portion.
- C. Notify the Architect in writing prior to Bid Submittal for clarification in a timely manner if:
 - 1. The Contractor does not clearly understand or is not completely sure of the meaning of any portion of the Mechanical Documents.
 - 2. Any ambiguity, discrepancy, inconsistency or omission in or between the Contract Documents exists or appears to exist regarding the mechanical systems.
- D. If a clarification request is not submitted or should a clarification, decision, or interpretation not be rendered, it is understood by all Parties that the Contractor will be rigidly held to the interpretation of the Architect with no additional monetary/time changes to the Contractor's original Bid.

1.07 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers stated in other parts of the Plumbing Documents are ones that the Engineer considers to be "quality" companies making the same type of equipment as the stated basis-of-design manufacturer and are provided as a convenience only. Due to the everchanging nature of the manufacturing field, a stated approved manufacturer may not be producing a true equivalent product at the time of the Bid Submittal. The Engineer is the final arbiter of the acceptability of a manufacturer.
- B. Equipment from all listed and approved manufacturers are subject to compliance with all stated requirements of the Plumbing Documents.

- C. Equipment manufacturers other than those listed must obtain authorization in accordance with the requirements of Division 1. When a manufacturer not listed is acceptable to the Engineer, it means that the manufacturer has been reviewed and judged as a maker of equipment which possess the similar performance qualities/characteristics and can fulfill the utilitarian functions without any apparent decrease in quality, durability, or efficiency.
- D. The granting of acceptable manufacturer to a company does not constitute acceptance of specific equipment. The Engineer does not pre-review any specific equipment prior to the Submittal/Shop Drawing Review process after the Bid.

1.08 ALTERNATE CONSTRUCTION

- A. Refer to Architect's portion of the Contract Documents for Alternate Construction Work to determine the increase or decrease in the contract price to your Base Proposal for each alternate requested.
- B. Coordinate and modify associated surrounding work as required to accommodate the alternate construction.

1.09 VALUE ENGINEERING (VE)

- A. All proposed VE items must be fully coordinated with all related aspects of the Project and other affected building systems. Proposed items must include:
 - 1. Specification (section and paragraph) and drawing (sheet/note, detail, and/or schedule) references related to the VE item .
 - 2. Full and complete information on the proposed VE material/equipment as required to allow the Engineer and Owner to make an informed decision.
 - 3. Denote variations from the originally specified material/equipment and any associated benefit/detriments to the Owner.
 - 4. Denote other building service(s) that will be affected .
 - 5. Estimated changes in the system's useful life.
 - 6. Changes to operational energy efficiency including part load capabilities and standby losses.
 - 7. Estimated changes to the Project's utility (water, fuel, electrical) usage.
 - 8. Changes required for flues, gas piping, combustion air, electrical service, domestic water service, or other sub-systems needed for the proposed equipment's proper installation and operation .
 - 9. Changes to space requirements for installation and maintenance.
 - 10. Total Project Cost Savings including all savings/increases for all affected building systems.
- B. Contractor is completely responsible to provide the burden of proof regarding the appropriateness for the intended use of a product. The Engineer is not responsible for performing any additional research to determine the appropriateness of the submitted item.

1.10 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1.
- B. Steel Pipe Welding: Qualify processes and operators according to ASME BPVC, Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.11 SUBMITTALS/SHOP DRAWINGS

- A. In addition to the requirements of Division 1; provide submittals, shop drawings, catalog data, descriptive literature (as applicable), and installation instructions for all items specified in Part 2- Products of all Division 22 Sections or for equipment noted/scheduled on the drawings in accordance with the Contract Documents and as hereinafter specified in any Division 22 section.

- B. Coordinate timing of submittals in accordance with Division 1 requirements, to provide adequate time for design professionals' review.
- C. Do not provide submittals/shop drawings for equipment that may be affected by the coordination process until after the resolution of the coordination process.
- D. Submit a specification compliance review where indicated in individual sections.
 - 1. At each paragraph of the specification indicate in the left hand margin if the paragraph "NA" not applicable, "C" complies or "E" exception. Explain fully any exceptions to the paragraphs. Shop drawings and product data will not be reviewed without submitting the specification compliance review.
- E. Action Submittals: As a minimum, submittals/shop drawings must conform to the following requirements.
 - 1. Submittal sheets/product data/shop drawings must be grouped to include complete submittals of related systems, products, and accessories in a single submittal.
 - 2. Reference must be made to the specific item's designation, specification section & paragraph, drawing number, and schedule /note/detail/diagram if applicable.
 - 3. Provide values or information for all items listed in the specification, schedules, or as noted elsewhere in the Plumbing Documents.
 - 4. Values must be in units to match those designated in the Plumbing Documents.
 - 5. If standard manufacturer's data or submittal sheets are utilized, they must be marked definitively and legibly to indicate specifically which size (s) or option(s) are being provided.
 - 6. Include diagrams for power and control/signal wiring.
 - 7. Include pump curves.
 - 8. Include a Statement of Compliance, on the manufacturer's letterhead, for the specified referenced standards if not included on their standard product data/submittal sheet.
 - 9. Manufacturer's standard color charts for selection of color by the Architect.
 - 10. If submitted equipment has not been available in the United States of America (US A) for a minimum of three (3) full years, submittal must include a list of installations in the USA and the year installed.
- F. Informational Submittals:
 - 1. Welding Certificates.
 - 2. Field quality-control reports
 - 3. A copy of the installation manual, if one is published by the manufacturer, must be included with all action submittals. They will not be reviewed by the Engineer but needs to be kept with the submittal on site during construction.
 - 4. A copy of the manufacturer's warranty.
- G. Samples: Not required for Division 22 items unless noted hereinafter in other Division 22 sections
- H. Sustainability Submittals: Comply with the requirements specified in Division 01 - Sustainable Design Requirements section(s) and as hereinafter specified. If not part of the Contract Documents, request a copy of the sustainability checklist to determine which plumbing system related sustainability requirements are being pursued.
 - 1. All proposed plumbing system components must not adversely affect the ability of this Project to achieve the desired sustainability rating.
 - 2. All proposed plumbing system components must not adversely affect the energy or water usage of the building.
 - 3. Field-applied adhesives and sealants must comply with the maximum sustainability VOC content limits.
- I. Completely and thoroughly review all submittals/shop drawings for conformance with the Contract Documents prior to forwarding it as specified in Division 1.
 - 1. Contractor is completely responsible to provide the burden of proof regarding the compliance with the document requirements or equivalency of a product. The Engineer will not be responsible for performing any additional research to determine the

- equivalency of the submitted item.
- 2. All requirements for the products shown in the Plumbing Documents must be adhered to and provided.
- 3. Submit complete information concerning all changes in the project required by the submitted products including detailed dimensional layouts of equipment, details of all required MEP service connections, clearances required for service and maintenance, weight, physical arrangement, engineering calculations, and all data necessary to assure that the equivalent product can be properly installed and operate in accordance with the requirements of the Contract Documents.
 - a. Review installation and maintenance information to determine if any changes or specific installation instructions are required for any associated building system.
- 4. Any re-engineering or design changes required for any associated building system to accommodate the proposed product must be coordinated and provided by the Contractor. Required changes must be in accordance with the Contract Documents and submitted for review by the Engineer. Examples include, but are not limited to, sizes of electrical wiring/conduits/breakers, gas piping, flues, combustion air ducts, etc.
- 5. Attention should be specifically given to the space limitations for the location of the submitted equipment and any manufacturer's recommended operational and maintenance clearances.
- J. Highlight and clearly call to the Engineer's attention:
 - 1. Any portion of the submittal/shop drawing that does not comply or varies from the Plumbing Document's requirements.
 - 2. Changes required for any associated building systems.
- K. If the Engineer has not noted an error in the Contractor's submittal, it does not relieve the Contractor from providing the correct material or equipment to fully comply with the Engineer's documents.
- L. Electronic copies of the Engineer's drawings may be obtained to use in preparing shop drawings for this specific project. A waiver provided by the Engineer must be signed and the required fee paid prior to the issuing of the sheets by the Engineer.
- M. Drawings obtained electronically from the Engineer or electronic reproductions of the Engineer's drawings are not to be considered of adequate detail to be submitted as a shop drawing. Submitted shop drawings must reflect the following required (but not limited to) for coordination
 - 1. Proposed equipment in lieu of the designed equipment.
 - 2. Specified items that are not shown on the Engineer's drawings.
 - 3. Items shown in details, diagrams, or required by drawing notes and schedules.
 - 4. Clearances around equipment required for access and maintenance.
 - 5. Elevations of piping and equipment.
- N. Submittal will be reviewed by the Engineer for design conformity and general compliance to the Engineer's Documents only. Contractor is completely responsible to confirm and correlate:
 - 1. Dimensions at the job site for tolerances and clearances.
 - 2. Quantities.
 - 3. Fabrication processes, techniques, and all other ways & means of construction.
 - 4. Coordination of the plumbing work with other building systems.
 - 5. Full compliance with the Contract Documents.
- O. The following are the responses used by the Engineer, a brief description of its meaning, and the subsequent action required by the Contractor. Submittals that contain multiple items may have multiple responses by the Engineer requiring multiple actions by the Contractor.
 - 1. "Reviewed, No Exception Taken": Item(s) submitted appears to meet the requirements of the Plumbing Documents.
 - a. No further submittal required.
 - 2. "Reviewed, Make Corrections Noted": Item(s) submitted appears to meet the requirements of the Plumbing Documents except for a few minor items noted.

- a. No further submittal required. Coordinate minor changes with the equipment supplier prior to ordering and update submittals for inclusion in the Operation and Maintenance Manuals.
3. "Revise and Resubmit": Manufacturer and general qualities of the item submitted meet the intent of the Plumbing Documents but major portions of the item are not acceptable or are missing from the submittal.
 - a. Revise the submittal to conform to the Plumbing Documents and resubmit.
 - 1) Only those items that require resubmittal or requested new information will be reviewed after the initial review by the Engineer. Contractor is completely responsible to ensure that no other changes have been made from the previous submittal.
4. "Rejected": Manufacturer is not equivalent to the Basis of Design or the model/item submitted is of a lesser quality/grade that does not conform to the Plumbing Documents.
 - a. Prepare a new submittal with completely different equipment and resubmit.
5. "Submit Specified Item": Item noted is left out of a submittal of related products.
 - a. Submit only the specific item(s) noted.
6. "Not Reviewed":
 - a. Submittal has not been reviewed/stamped by the Contractor or is so bad or illegible that a proper review cannot be performed by the Engineer.
 - 1) Prepare a new submittal and resubmit.
 - b. Submittal is for an item not specified in Division 22 but some portion of the submittal needs to be coordinated for connection to a Division 22 system.
 - 1) No further submittal to the Engineer required. Coordinate minor changes with the equipment supplier prior to ordering.
- P. Obtain a positive review (Reviewed, No Exception Taken or Reviewed, Make Corrections Noted) of the material before delivery to the job site.
- Q. Where a submitted product has received a positive review by the Engineer, it does not relieve the Contractor from the responsibility for making all changes in the work necessary and required for a proper and fully functioning installation of the product.

1.12 PRE-CONSTRUCTION COORDINATION

- A. Coordinate the installation of new work with the utility company's requirements.
- B. Location and routing of the plumbing components must be coordinated with all other building systems prior to installation. First system installed does not settle coordination issues.
- C. As the result of coordination meeting(s) prior to construction, prepare a 3-D model to resolve conflicts between all building components and systems.
 1. Contact the Architect to determine the availability and requirements to obtain the electronic building model (drawings) for the verification of all building elements and their dimensions.
- D. Prepare plans drawn to 1/4" = 1'-0" scale with the following items shown and coordinated with other building system components being installed in the same area or space. Utilize the 3-D model if required by Division 1.
 1. Fabrication, assembly and installation of the plumbing systems including plans, elevations, sections, components, and attachments to other work.
 2. Establish and maintain clearance requirements for the field installation of insulation/jackets/finishes and for space required for maintenance.
 3. Pipe layout indicating sizes, configuration, elevation, and slope if required.
 4. Location and access/maintenance clearances for pipe accessories including but not limited to isolation valves, balancing valves, control valves, and access panels/doors.
 5. Dimensions of main pipe runs from building grid lines.
 6. Penetrations through fire-rated and other partitions.
 7. Installation of submitted/positively reviewed equipment including maintenance clearances.
 8. Location of ceiling components such as light fixtures, air inlets/outlets, sprinkler heads, speakers, fire alarm devices, motion detectors, etc. Allow sufficient space for ceiling panel

removal. As a rule of thumb, light fixtures get top priority for location in the ceiling. HVAC diffusers/register/grilles get second priority. Sprinkler heads third priority. Then all other devices. (Note: If number of sprinkler heads can be reduced by installing in a certain location, it shall take precedent over the air device if relocation of the air device does not significantly affect HVAC system performance. Coordinate proposed diffusers/registers/grilles relocations with the Engineer.)

9. Structural components.
- E. When mounting heights of hung plumbing system components are not detailed or dimensioned in the Plumbing Documents, install components to provide the maximum headroom possible
 1. Components in mechanical equipment rooms may be mounted lower to facilitate operation and maintenance. Bottom of any exposed component or support hanger must be minimum 7'-0" above the finished floor unless noted otherwise in the Plumbing Documents.
 2. If any component must hang below 7'-0", all surfaces must be covered with a brightly-colored, OSHA-approved, soft protective covering to prevent physical harm.
- F. Bid shall include sufficient fittings, material, and labor to allow for adjustment in routing of the plumbing systems made necessary by the coordination process.

1.13 INSPECTIONS

- A. Contact AHJ(s) and coordinate the requirements, timing, and completion of all required inspections.
- B. Do not enclose, cover, insulate or put into operation any portion of the plumbing systems required by the AHJ(s) to be inspected.
- C. Furnish all material, equipment, tools, temporary connections, labor, and services as required by the AHJ(s) that allows them to complete their inspection(s).
- D. If a portion of the plumbing system does not pass tests or inspections, make required corrections and arrange for re-inspection.

1.14 OBSERVATION OF THE WORK

- A. Site visits by the Engineer will consist of visual observations of the construction to permit the Engineer to render their professional opinion as to the Contractor's conformance to the intent of the Plumbing Documents. Given the inherent limitations of such inspections, they can not be relied upon by any party as acceptance of the work nor will they relieve any party from fulfillment of customary and contractual responsibilities/obligations.
- B. The Engineer does not have the right to reject work or the right/duty to stop work.
- C. Construction observation report(s) may recommend rejection of the work which, in the Engineer's professional opinion, does not conform to the intent of the Plumbing Documents or applicable Code requirements.
- D. The fact that the Engineer has failed to observe and/or documented work that is faulty or is not in accordance with the Plumbing Documents does not relieve the Contractor from the responsibility of correcting such work.
- E. Although the Engineer may confer on site with the Contractor regarding interpretation of the Contract Documents, such assistance does not relieve the Contractor of any responsibility from performing all required work.
- F. The Engineer does not have the right to change the requirements of the Contract Documents in any way. Any statements made by the Engineer regarding their opinion on the suitability of any Contractor proposed modifications of the plans and specifications shall not be interpreted by anyone as an authorization to change the requirements of the Contract Documents. All Contractor proposed changes to the Contract Documents must be made to and accepted by the Architect in writing.
- G. Compliance with OSHA requirements or other statutory safety requirements is the complete responsibility of the Contractor.

- H. Prior to the Engineer's final construction observation (for all or any portion of the Project), the Contractor shall provide the Engineer with the Contractor's observation report that was made prior to the Engineer's visit.
 - 1. Provide a set of plumbing drawings that have been used by the Contractor to verify the installation of all components. Verified items must be highlighted. Drawings must include floor plans, risers, and details that indicate all required components.

1.15 WARRANTY

- A. Warrant the installed mechanical systems are fully coordinated, complete, and properly functioning as outlined in the Construction documents. This shall include, but not be limited to, the following:
 - 1. Any defects due to faulty workmanship or material.
 - 2. All raceways are free from foreign material, obstructions, holes or breaks of any nature.
 - 3. All equipment is fully functioning to the intent of their sequence of operation.
 - 4. All piping systems have proper circulation.
- B. Upon written notice from the Architect or Owner, promptly remedy any defects occurring within the Project's Base Warranty Period from the date as directed by the Architect.
- C. Contractor is personally responsible to replace any equipment or portion of that equipment whose manufacturer's warranty is based on "time from shipment" which has expired prior to the end of the Project's Base Warranty Period or any specified special warranty period(s). Extended manufacturer's warranties may be utilized to provide coverage for the required warranty period(s) and shall be included in the Contractor's Bid.
- D. The Project's Base Warranty Period does not supersede any extended warranty periods hereinafter specified.

1.16 PROJECT CLOSEOUT

- A. Closeout Procedures, Project Record Documents, and Operation and Maintenance Data must be in accordance with Division 1 and as hereinafter specified.
- B. Furnish Record Drawings showing all changes (whether generated by addenda, submittals, change orders, implemented request for information, field discovered condition, or construction coordination) in construction from that shown on the original Contract Documents in the manner as specified in Division 1.
- C. At the front of the plumbing portion of the Operation and Maintenance Data, provide a typed Installer's Information List including the General Contractor and any Sub-Contractors who performed part of the Plumbing System installation. Paper page must be inserted in a heavyweight, non-glare, plastic sheet protector or the information can be printed on a piece of 8.5"x11" card stock with holes punched for binding as specified in Division 1. Information for each contractor must include:
 - 1. Name of Company.
 - 2. Company Address.
 - 3. Company Phone Number.
 - 4. Company General Email Address.
 - 5. Contact Person in Company with their specific Phone Number and Email Address.
 - 6. Portion of work performed by Company with reference to Specification Section(s) and Drawing Number(s).
- D. Plumbing portion of the Operation and Maintenance Data must include:
 - 1. Installer's Information List.
 - 2. All equipment, fixtures, and specialties furnished under Division 22 must have the following grouped together in accordance with Division 1 requirements.
 - a. A clean copy of all approved shop drawings marked definitively and legibly with all changes (whether generated by addenda, change orders, or field discovered condition, etc.) in equipment from those shown on the original contract documents.
 - b. Manufacturer's Installation, Operation, & Maintenance (I/O/M) Manual/Instructions.
 - c. Manufacturer's parts list if not included in the I/O/M Manual/Instructions.

- d. Manufacturer's recommended maintenance clearances if not included in the I/O/M Manual/Instructions.
- e. Any other Manufacturer's current printed data that would help the Owner in operating, maintaining, or modifying the installed system in the future.
- f. Copy of all Warranties.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR MATERIAL AND EQUIPMENT

- A. All acceptable manufacturers listed for each item are completely subject to all requirements listed in the Mechanical Documents for that item.
- B. Basis of Design manufacturers and model numbers used in the Plumbing Documents establish the type and basic quality required. Products must be provided with:
 - 1. All standard devices/accessories/features as indicated in the latest edition of the manufacturer's catalog/brochure/website published at the date of the Bid.
 - 2. Any options or modifications as stated in the Plumbing Documents.
 - 3. Any options or modifications as required for its proper installation or obvious intended use.
- C. All plumbing components must comply with the following.
 - 1. Manufactured by a company in the everyday business of producing that item.
 - 2. New (not previously used or re-manufactured), of the best quality, and free from defects.
 - 3. Have a minimum pressure rating equal to or greater than the system operating pressure.
- D. Each type of plumbing component must be manufactured by a single company and be obtained from one wholesaler/supplier.
 - 1. Exception: Commodity items.
- E. All equipment provided for the Project must meet or exceed all minimum values and must not exceed all maximum values indicated in the Plumbing Documents.
- F. All equipment and systems must be coordinated with all other associated equipment and systems.
- G. All material and equipment can not contain any asbestos, lead, mercury/mercury compounds, urea-formaldehyde resin, or other EPA- recognized hazardous material of any kind or form.
- H. All equipment must be equipped with warning and information signs and labels in accordance with ANSI Z35.1.
- I. Pipe and fittings shall be of nominal diameter as designated, with inner/outer surfaces concentric, smooth inside, straight, and free from weld flaws, blisters or other defects.
- J. Each length of pipe and each fitting shall have cast, stamped or indelibly marked on it the maker's mark or name and the weight and quality of the product where such marking is required by the approved standard that applies.
- K. Surface-Burning Characteristics:
 - 1. All plumbing system materials and components must be noncombustible or listed/labeled by a NRTL recognized by the AHJ, indicating that they do not exceed the required flame-spread/smoke-developed index when tested in accordance with ASTM E84 or UL 723.
 - 2. Interior: Flame-spread index of not more than 25 and a smoke-developed index of not more than 50
 - 3. Exterior: Flame-spread index of not more than 75 and a smoke-developed index of not more than 150.
 - 4. Required flame-spread/smoke-developed index shall be indicated on all materials/components or their shipping cartons.

2.02 DOMESTIC WATER REQUIREMENTS

- A. All pipes, fittings, solder, and flux used in the construction of the domestic water system and the wetted surfaces of any plumbing component that is in contact with the domestic water must be certified lead-free in compliance with:
 - 1. "Drinking Water System Components – Health Effects".
 - 2. "Drinking Water System Components – Lead Content".

3. "Safe Drinking Water Act - Amended 2011".
- B. All materials in contact with domestic water must be American Water Works Association (AWWA) or U.S. Food and Drug Administration (FDA) approved.
- C. Lead-free alloys used for all components must not require special soldering procedures or material.
- D. Copper alloy requirements: Copper alloy components in contact with domestic water (wetted surface) shall be de-zincification resistant (DZR), and be so labeled, unless noted otherwise in the Plumbing Documents.

2.03 SUSTAINABILITY REQUIREMENTS

- A. For field applications of adhesives, mastics, paint, or other material that are in the interior of the building, the VOC content cannot be greater than the requirements specified in Division 01 - Sustainable Design Requirements section(s).

2.04 PIPE ESCUTCHEONS

- A. Manufactured escutcheons with a center opening diameter to closely fit around bare or insulated pipe, with an outside diameter that completely covers penetration opening.
- B. Steel: IPS 1/4 – 10 inches and CPS 3/8 – 4 inches: Split-face type with spring-closed concealed hinge, locking tabs, set screw or spring clips, and chrome-plated finish.

PART 3 EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store and handle all plumbing components in accordance with manufacturer's recommendations.
- B. While temporarily storing plumbing components, do not exceed the structural capacity of the floor.
- C. Items intended for indoor installation can not be stored exposed to outdoor weather conditions.
- D. Any plumbing component that can be damaged by water must be protected from direct contact with rain, sprayed water, runoff, standing water, or any other type of moisture that will soak into or corrode the component. Items that have absorbed water or have been prematurely corroded can not be utilized on the Project.
- E. Any plumbing component that can be damaged by direct sunlight must be protected .
- F. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent damage and entrance of dirt, debris, and moisture.
- G. Maintain any factory-applied protective coatings during construction until removal is required for system testing or final cleaning.
- H. Any plumbing component that has been damaged during delivery, storage, or construction before final acceptance by the Owner must be repaired or replaced to return the item to a "like new" condition in a manner approved by the Architect.
 1. Repair: This method may be used if a plumbing item can be repaired by field correcting or replacing the damaged component of that item without affecting the item's warranty, service life, construction integrity, or visual appearance. All work must be done in strict accordance with the manufacturer's instructions, requirements, and/or supervision.
 2. Replace: This method must be used if, in the Architects opinion, the damage is too great to warrant a simple repair, the appearance of the item cannot be returned to a state where the original damage cannot be detected, or if the damage/repair voids any portion of the items warranty.

3.02 EARTHWORK

- A. Comply with requirements in Division 31 "Earthwork" for excavating, backfilling, and compaction of utility trenches for all below-slab or below-grade plumbing piping.

3.03 GENERAL INSTALLATION REQUIREMENTS

- A. All work must be done in a manner and appearance acceptable to the Architect.

- B. Installation must be performed in a professional manner as required by the most stringent of the following:
 - 1. The Plumbing Code referenced in the Architectural Code Review portion of the Contract Documents.
 - 2. As required by the Plumbing Documents.
 - 3. General piping: American Society of Testing and Material (ASTM) requirements.
 - 4. Copper pipe: Copper Development Association (CDA) requirements.
 - 5. Steel pipe: American Society of Mechanical Engineers (ASME) requirements.
 - 6. Cast Iron Pipe: Cast Iron Soil Pipe Institute (CISPI) requirements.
 - 7. Equipment, specialties, manufactured fittings, and specialized piping types: Manufacturer's requirements.
- C. Inspect and verify that all construction conditions affecting the work are acceptable before beginning installation of the plumbing systems.
- D. Notify the Architect as specified in Division 1 before proceeding with the work if a conflict arises between the work under this Section and other work.
- E. Do not proceed with the installation until unacceptable conditions are corrected.
- F. Piping can not be installed through any solid structural component unless approved in writing by the Architect and Structural Consultant prior to the installation. Piping may be routed thru the open web of steel bar-joists or trusses.
- G. Install piping concealed from view except for the following locations:
 - 1. If noted or shown to be exposed in finished areas on the drawings.
 - 2. Spaces without ceilings.
 - 3. Equipment rooms.
 - 4. Service areas.
- H. Installation of piping must conform to the following requirements.
 - 1. Be free of sags and bends.
 - 2. Be routed at right angle or parallel to building walls and other piping. Diagonal runs are prohibited above grade unless specifically indicated otherwise.
 - 3. Utilize fittings for all changes in direction, branch connections, and size changes.
 - 4. Permit the best accessibility for valve operation and servicing.
 - 5. Connect to equipment, fixtures, and specialties with a means of mechanical disconnection to allow removal of the plumbing component with minimum or no piping or specialties removal.
 - 6. Can not block maintenance or service access to plumbing components or any other building system component or equipment.
 - 7. Allow insulation to be installed and properly sealed completely around individual pipes.
 - 8. Allow sufficient space for ceiling panel removal above lay-in ceilings.
- I. Installation of plumbing equipment and specialties must conform to the following requirements.
 - 1. Be in accordance with the manufacturer's recommendations (including technical manuals, guides, bulletins, or submittals), in compliance with all Codes and referenced standards, and as required by the Contract Documents; whichever is more stringent. If the most stringent requirement(s) conflicts with the manufacturer's recommendation, bring the conflict to the Architect's attention for clarification prior to installation.
- J. Be level, plumb, and parallel/perpendicular to the building structure and other building systems' components unless otherwise indicated.
- K. Be positioned to facilitate service, maintenance, repair, or replacement of the equipment or one of its components.
- L. Allow maximum possible headroom unless specific mounting heights are indicated.
- M. Allow right of way for piping installed at required slope.
- N. All floor-mounted equipment must be mounted on concrete housekeeping pads. Metal legs, skids, or bases that are part of the equipment are not adequate.

3.04 MISCELLANEOUS CONSTRUCTION COORDINATION

- A. Coordinate and arrange for spaces, chases, slots, sleeves, and openings in the building structure and general construction during the progress of the Project to allow for proper plumbing system installations.
- B. Coordinate installation of required supporting devices.
- C. Access Doors: Coordinate size and location requirements for doors providing access to plumbing equipment and specialties requiring maintenance or periodic inspection which are concealed behind non-removable finished building surfaces. Minimum size of access door openings must be as follows or greater as required for plumbing component maintenance or removal. Coordinate exact sizes with the Architect.
 - 1. One-Hand or Inspection Access: 8 x6 inches
 - 2. Two-Hand Access: 12x6 inches
 - 3. Head and Hand Access: 18x12 inches
 - 4. Body Access: 24x18 inches
 - 5. Body plus Ladder Access: 24x24 inches

3.05 PIPE ESCUTCHEON INSTALLATION

- A. Escutcheons for individual fixture supply stop may be supplied with the valve.
- B. Install escutcheons for exposed pipe penetrations of walls and ceilings in finish spaces.
- C. Escutcheons for any type of pipe or conduit penetration of a fire or smoke walls must be metal type.
- D. All visible escutcheons in a single space must be of the same type as approved by the Architect.
- E. Insulated pipes: Interior dimension of escutcheon must closely match exterior dimension of insulation.
 - 1. For metal escutcheons, neatly and professionally provide a non-combustible spacer between insulation and the escutcheon or securely fasten escutcheon to the wall/ceiling so the pipe is centered in the escutcheon.
- F. Escutcheons must not be abutted to the adjoining surface until:
 - 1. Final finish of the adjoining wall or ceiling surface is complete.
 - 2. Installed firestopping at the pipe penetration has been inspected.

3.06 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 for structural steel supports for plumbing systems
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.07 DAMAGE AND TOUCH-UP PAINTING

- A. Painting of plumbing systems, equipment, and components is specified in Division 09.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures as provided by the equipment manufacturer to match the original factory finish and in a manner/appearance acceptable to the Architect.

3.08 PROTECTION AND CLEANING

- A. Keep areas clear of debris during construction. Promptly remove waste material from premises.
- B. Clean all exposed plumbing components in finished and unfinished areas.
- C. Thoroughly clean both the accessible inside and the entire outside of all equipment.
- D. Take measures to protect completed areas and/or existing areas of the building from the migration of construction-generated contaminants.

END OF SECTION

**SECTION 22 05 13
COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Summary: General requirements for three-phase, general-purpose, squirrel-cage, induction motors for use on alternating-current (AC) power systems up to 600 volts and installed at equipment factory or shipped separately by equipment manufacturers for field installation.
- B. General construction and requirements.
- C. Three phase electric motors.

1.02 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 1 - Motors and Generators 2021.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 SUBMITTALS

- A. See Division 1 for submittal procedures and general requirements.
- B. Provide the following motor information with the submittal for the associated piece of equipment:
 - 1. Product Data: Outlining compliance with this sections Part 2 requirements.
 - 2. Manufacturer's Installation Instructions: Including lubrication, and wiring instructions.
 - 3. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.
 - 4. Operation Data: Include instructions for safe operating procedures.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacture of electric motors and their accessories with a minimum three years documented product development, testing, and manufacturing experience.
- B. Comply with NFPA 70.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.05 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with:
 - 1. Torque, speed, and horsepower requirements of the load.
 - 2. Rating and characteristics of the connected power circuit and required control sequence.
 - 3. Ambient and environmental conditions of the installation location.
 - 4. Motor controllers.

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 WARRANTY

- A. See Division 1 regarding closeout submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for inverter duty motors.

PART 2 PRODUCTS

2.01 MANUFACTURERS:

- A. Subject to compliance with all requirements, provide products by one of the manufacturers listed below unless noted differently in the Contract Documents.
 - 1. Baldor.
 - 2. General Electric.
 - 3. Marathon.
 - 4. Lincoln.
 - 5. MagneTek/Century.
 - 6. Gould.
 - 7. Toshiba.
 - 8. Reliance.
 - 9. US Motors.

2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service:
 - 1. Motors Larger than 1/2 Horsepower: Three phase, 60 Hz.
- B. Nominal Efficiency:
 - 1. Premium-efficiency complying with EISA 2007.
- C. Construction:
 - 1. Open drip-proof type except where specifically noted otherwise.
 - a. Motors located outdoors: Totally enclosed weatherproof epoxy-sealed type.
 - 2. Design for continuous operation in 104 degrees F environment and an altitude of 3300 feet above-sea-level.
 - a. Additionally be rated for operation up to 6600 feet above-sea-level.
 - 3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
 - 4. Enclosure Material:
 - a. 3/4 hp: Stainless-steel.
 - b. 1 hp and larger: Cast-iron with polyurethane enamel or equivalent paint.
- D. 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.
- E. Wiring Terminations:
 - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
 - 2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.03 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Motor shall be sufficient to start, accelerate, and operate connected load at designated speed, at installed altitude/environment, with indicating operating sequence, and without exceeding nameplate rating or considering service factor.
- B. Size of motor shall be non-overloading under all possible conditions of operation.
- C. NEMA Starting Code Designation:
 - 1. 10 hp and smaller: Manufacturer's standard starting characteristics.
 - 2. 15 hp and Larger: NEMA Locked Rotor kVA/HP Code F or G.
- D. Design, Construction, Testing, and Performance: Comply with NEMA MG 1 for Design B motors.
- E. Temperature Rise: Minimum NEMA Class B.
- F. Insulation System: Minimum NEMA Class F.
- G. Testing Procedure: In accordance with IEEE 112. Load test motors to determine that they are free from electrical or mechanical defects in compliance with performance data.

- H. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- I. Thermistor System for Motor Frame Sizes 254T (7-1/2 hp) and Larger: Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.
- J. Bearings:
 - 1. 5 hp and Smaller: Permanently lubricated ball bearings.
 - 2. 7-1/2 hp and Larger: Grease-lubricated, shielded, 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 and suitable for radial and thrust loading.
 - 3. Stamp bearing sizes on nameplate.
- K. Nominal Efficiency: As indicated at full load and rated voltage when tested in accordance with IEEE 112.
- L. Nominal Power Factor: As indicated at full load and rated voltage when tested in accordance with IEEE 112.
- M. Motors used with variable frequency drives (VFDs) shall be inverter duty and shall include the following additional requirements.
 - 1. Windings: Copper magnet wire with non-hygroscopic, anti-fungus insulation system designed and tested to resist transient spikes, high frequencies, and short-term rise pulses produced by pulse-width-modulated inverters.
 - 2. Meet NEMA corona inception voltage requirements to withstand peak voltage < 1800 volts and manufactured in accordance with NEMA MG1-31.
 - 3. Shaft grounding rings: Factory-installed shaft grounding rings, as hereinafter specified, whenever possible. Field-installed shaft grounding rings shall only be used if they cannot be factory-installed.

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 SCHEDULES

- A. NEMA Open Motor Service Factors.
 - 1. 3/4 hp:
 - a. 1800 rpm: 1.25.
 - 2. 1 hp:
 - a. 1800 rpm: 1.15.
 - 3. 1.5-150 hp:
 - a. 1800 rpm: 1.15.

END OF SECTION

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SECTION 22 05 16
EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Flexible pipe connectors.
- B. Expansion joints and compensators.

1.02 RELATED REQUIREMENTS

- A. Section 22 10 05 - Plumbing Piping.

1.03 REFERENCE STANDARDS

1.04 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 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.
- B. Project Record Documents: Record installed locations of flexible pipe connectors, expansion joints, anchors, and guides.

PART 2 PRODUCTS

2.01 FLEXIBLE PIPE CONNECTORS - STEEL PIPING

- A. Inner Hose: Carbon steel.
- B. Exterior Sleeve: Single braided, stainless steel.
- C. Joint: As specified for pipe joints.
- D. Size: Use pipe sized units.
- E. Maximum offset: 3/4 inch on each side of installed center line.

2.02 FLEXIBLE PIPE CONNECTORS - COPPER PIPING

- A. Inner Hose: Bronze.
- B. Exterior Sleeve: Braided bronze.
- C. Joint: As specified for pipe joints.
- D. Size: Use pipe sized units.
- E. Maximum offset: 3/4 inch on each side of installed center line.
- F. Application: Copper piping.

PART 3 EXECUTION

3.01 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. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.

END OF SECTION

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SECTION 22 05 17
SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe sleeves.
- B. Manufactured sleeve-seal systems.

1.02 RELATED REQUIREMENTS

- A. Division 7 for joint sealant and firestopping.

1.03 SUBMITTALS

- A. See Division 1 for submittal procedures.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.

1.04 QUALITY ASSURANCE

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 WARRANTY

- A. See Division 1 for additional warranty requirements.

PART 2 PRODUCTS

2.01 PIPE SLEEVES

- A. Steel Sheet: Minimum 0.0239 inch thickness galvanized steel formed to a round tube and closed with welded longitudinal seam.
- B. Steel Pipe: ASTM A53, Type E, Grade B, Schedule 40, galvanized, plain end.
- C. Polyvinylchlorene (PVC) Pipe, ASTM D1785, Schedule 40
- D. Pre-manufactured sleeves:
 - 1. Stack sleeve fitting:
 - a. Manufacturer:
 - 1) Jay R. Smith
 - 2) Zurn
 - b. Coated, cast-iron sleeve with integral, fixed-position combination membrane flashing flange/deck clamp including nuts/bolts of required length.
 - 2. Reusable molded hole forms shall be made from polyethylene (PE) or polypropylene (PP) plastic material with smooth outer surface and nailing flange for attaching to wooden forms for poured concrete construction.
 - 3. Cast-in-place with waterstop:
 - a. Manufacturer:
 - 1) Advance Products & Systems - "Infinity".
 - 2) GPT - "Century-Line"
 - b. High Density Polyethylene (HDPE) thermoplastic sleeve with molded-in full-circle waterstop, reinforcing ribs and nailer end caps.

2.02 MANUFACTURED SLEEVE-SEAL SYSTEMS

- A. Manufacturers:
 - 1. Advance Products & Systems - "Innerlynx":
 - 2. Calpico, Inc. - "Pipe Linx"
 - 3. GPT - "Link-Seal"
 - 4. Metraflex - "MetraSeal"
- B. Modular/Mechanical Seal:
 - 1. Ethylene peopylene diene monomer (EPDM) rubber interlocking links continuously fill annular space between pipe and wall opening or sleeve.
 - a. Utilize nitrile butydiene rubber (NBR) in lieu of EPDM for gas or oil piping.
 - 2. Provide watertight seal between pipe and sleeve/formed or core-drilled construction penetration.
 - 3. Elastomer element size and material in accordance with manufacturer's recommendations.
 - 4. Pressure Plates: Glass reinforced plastic. Two for each sealing element.
 - 5. Connecting Bolts and Nuts: Stainless-steel of length required to secure pressure plates to sealing elements. One per each sealing element,

PART 3 EXECUTION

3.01 PREPARATION

- A. Cut ends of steel, PVC, or HDPE sleeves square.
- B. Ream ends and remove burrs from steel sleeves.
- C. Remove scale and foreign material, from inside and outside, before assembly.

3.02 SLEEVE INSTALLATION

- A. Sleeves shall be fully coordinated with the:
 - 1. Building's general construction
 - 2. Pipe routing/slope. Sleeves shall not interfere with the required slope of the installed pipe.
 - 3. Pipe insulation. Sleeves shall not require the compression of pipe insulation.
 - 4. Fire or smoke-rated building construction. Insure that sleeves comply with the selected Division 7 firestopping pipe-through-penetration system's minimum requirements.
 - a. Firestopping requirements supercedes all other specified or detailed sleeve requirements.
- B. Install permanent sleeves for all pipes passing through:
 - 1. Framed walls or partitions.
 - 2. Framed floor/ceiling assemblies.
 - 3. Framed roof/ceiling assemblies.
 - 4. Masonry walls or partitions.
 - 5. Slab-on-grade, poured-in-place concrete floors.
 - a. Not required for single, floor-mounted plumbing fixtures.
 - 6. Below-grade, poured-in-place concrete floor and wall penetrations in high hydrostatic soils.
 - 7. Corrugated steel pan/concrete floor or roof slabs if depth of construction is inadequate for required sealing.
- C. Permanent sleeves are not required for:
 - 1. Formed or core-drilled penetrations through solid concrete construction except as noted above.
 - 2. Corrugated steel pan/concrete floor or roof slabs unless as noted above.
 - 3. Membrane penetrations of framed or concrete block construction.
- D. Install sleeves in new walls, floors, roofs, assemblies, etc.as they are being constructed.
- E. Sleeves in framed assemblies shall be supported and securely fastened to a piece of framing material attached to adjacent structural framing. Assembly membrane material shall not

support the sleeve.

- F. Each individual pipe shall have its own sleeve. Adjacent sleeves shall have a minimum centerline spacing as follows:
 - 1. Horizontal sleeves through walls or partitions: Two (2) diameters of the largest adjacent sleeve.
 - 2. Vertical sleeves through floors or roofs: Three (3) diameters of the largest adjacent sleeve.
- G. Sleeves for insulated pipe.
 - 1. Interior construction: Allow the full insulation thickness to pass through the sleeve.
 - 2. Exterior construction: Allow the full exterior insulation thickness to pass thru the sleeve.
- H. Sleeve Dimensions.
 - 1. Length: Ends of the sleeve shall be flush to the both faces of the penetrated construction, including any masonry or other veneer.
 - 2. Diameter shall be sized:
 - a. To allow no less than 1/4 inch annular space between the outside dimension of the pipe/pipe insulation and the interior dimension of the sleeve/formed or core-drilled penetration.
 - b. To permit sufficient pipe movement due to expansion/contraction perpendicular to the construction penetration.
 - c. In compliance with the mechanical sleeve seal manufacturer's requirements.
- I. Sleeves shall be tight to the general construction's penetrated membrane. Seal minor imperfections around the sleeve as follows:
 - 1. Masonry: Grout.
 - 2. Framed assemblies: Joint sealant.
 - 3. Fire-rated general construction: Firestopping caulk.
- J. Fill the annular space between the pipe/pipe insulation and the sleeve/formed or core-drilled penetration as follows:
 - 1. Interior:
 - a. If not stated otherwise below: 3/4 lb. density bare fiberglass insulation compacted for the full length of the sleeve/penetration.
 - b. Slab-on-grade concrete floors:
 - 1) Standard soil conditions: Grout.
 - 2) High hydrostatic soil conditions: Mechanical sleeve seals.
 - c. Above grade floors or floor/ceiling assemblies.
 - 1) Standard: Joint sealant appropriate for size, depth, and location. Utilize backing if required. Architect to approve color.
 - 2) With waterproof membrane: No sealant required for use with stack sleeve fitting with membrane clamp.
 - d. Any sound-barrier walls, floors, or floor/ceiling assembly around a space where noise is generated, noise is desired to be kept out, or privacy is required: Mechanical sleeve seal.
 - 2. Exterior:
 - a. Walls above grade, 1 NPS or smaller: Joint sealant appropriate for size, depth, and location. Utilize backing if required. Architect to approve color.
 - b. Walls above grade, 1-1/4 NPS or larger: Mechanical sleeve seal.
 - c. Walls below grade: Mechanical sleeve seals.
- K. Structural Considerations:
 - 1. Do not penetrate building structural members unless pre-approved in writing by the Architect and Structural Engineer. Provide sketch for proposed size and routing. Annular space shall be in accordance with the Structural Engineer's recommendations for possible building settling but no less than as stated above
- L. Manufactured Sleeve-Seal Systems:
 - 1. Provide sealing elements of the size, quantity, and type required for the piping and sleeve or construction penetration inner diameter.

2. Locate piping in center of sleeve or penetration.
3. Install field assembled sleeve-seal system components in annular space between sleeve/construction penetration and piping.
4. Tighten bolting for a water-tight seal.
5. Install in accordance with manufacturer's recommendations.

3.03 SLEEVE SCHEDULE

- A. Steel Sheet Sleeves:
 1. Interior or exterior, non-bearing walls or partitions.
 2. Floor/ceiling assemblies.
 3. Roof/ceiling assemblies.
- B. Steel Pipe Sleeves.
 1. Interior or exterior, framed or masonry bearing walls.
 2. Exterior, tilt-up, insulated concrete panels.
 3. Any sound-barrier walls, floors, or floor/ceiling assemblies.
- C. PVC Pipe Sleeves: New slab-on-grade poured-in-place concrete floors.
- D. Stack Sleeve Fittings: Above slab floors with integral waterproof membrane.
- E. Reusable Molded Hole Forms: New above grade, poured-in-place concrete floors and roofs.
- F. Cast-in Place Sleeves: New, below-grade, poured-in-place concrete floor and wall penetrations in high hydrostatic soils. Refer to soils test report or as observed during construction.

3.04 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.
- C. See Division 1 for additional requirements.

END OF SECTION

SECTION 22 05 19
METERS AND GAUGES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Applications: Devices in this section are for the following plumbing systems.
 - 1. Domestic water.
 - 2. General service compressed air.
- B. Water meters.
- C. Pressure gauges and tappings.
- D. Thermometers and thermowells.
- E. Test plugs and kit.
- F. Sight flow indicators.

1.02 ABBREVIATIONS AND ACRONYMS

- A. CNR: Copper nickel (90-10) alloy.
- B. CRES: Corrosion-resistant steel (stainless steel).
- C. CSA: Carbon steel.
- D. CUNI: Copper nickel (70-30) alloy.
- E. EPDM: Ethylene-propylene diene monomer synthetic rubber.

1.03 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments 2022.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers 2014 (Reapproved 2020).
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers 2014 (Reapproved 2021).
- D. AWWA C700 - Cold-Water Meters -- Displacement Type, Metal Alloy Main Case 2020.
- E. UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Division 1 for submittal procedures.
- B. Product Data:
 - 1. Manufacturers catalog information.
 - 2. List that indicates use, operating range, total range and location for manufactured components.
 - 3. Items for domestic water installation shall state that their wetted surface components are lead-free and de-zincification resistant.
- C. Project Record Documents: Record actual locations of components and instrumentation.
- D. Operation and Maintenance Data: Include an approved copy of this submittal, manufacturers descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.05 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 GENERAL DOMESTIC WATER REQUIREMENTS

- A. Items for domestic water installation shall have wetted surface components that:
 - 1. Are lead-free in compliance with NSF 61 and NSF 372.

2. Utilize copper alloys that are de-zincification resistant (as defined as containing no more than 15% zinc) and contain additional alloy elements that deter de-zincification.

2.02 WATER METERS

- A. This specification does not apply to the main water service meter required by the Utility.
- B. Positive Displacement Meter - 2 NPS and Smaller:
 1. Basis of Design: Badger Recordall disc-type.
 2. Standard: AWWA C700.
 3. Type: Nutating disc.
 4. Meter Housing and Bottom Plate: Bronze.
 5. Measuring Chamber and Disc: Engineered plastic.
 6. Magnet: Ceramic.
 7. Trim: Stainless-steel.
 8. Strainer, Integral: Stainless-steel or engineered plastic.
 9. Register/Encoder: Hermetically sealed in tamper-proof engineered plastic lid and shroud compatible for remote reading by a BMS. Readout shall be in gallons.
 10. Connections: Threaded for 1 NPS and smaller. Flanged for 1-1/2 NPS and 2 NPS.
 11. Minimum Operating Range:
 - a. 5/8 NPS: 0.5 - 25 gpm.
 - b. 3/4 NPS: 0.75 - 35 gpm.
 - c. 1 NPS: 1 - 55 gpm or 1.25 - 70 gpm.
 - d. 1-1/2 NPS: 2.5 - 120 gpm.
 - e. 2 NPS: 2.5 - 170 gpm.
 12. Maximum Operating Temperature: 80 degree F.
 13. Maximum Operating Pressure: 125 psig.
 14. Accuracy: $\pm$ 1-1/2 percent
 15. Maximum Counter Reading: 10 million gallons.
- C. Turbine Meter - 3 NPS and Larger.
 1. Basis of Design: Badger Recordall.
 2. Standard: AWWA C701.
 3. Type: Direct coupled turbine.
 4. Meter Housing: Bronze.
 5. Turbo Head: Bronze.
 6. Nose Cone, Straightening Vanes, & Rotor: Thermoplastic
 7. Rotor Bearings.
 - a. Radial: Lubricated thermoplastic.
 - b. Thruster: Sapphire jewels.
 - c. Pivot:.
 8. Strainer, Integral: Stainless-steel
 9. Magnet: Ceramic.
 10. Trim: Stainless-steel.
 11. Strainer, Integral: Stainless-steel or engineered plastic.
 12. Register/Encoder: Hermetically sealed in tamper-proof engineered plastic lid and shroud compatible for remote reading by a BMS. Readout shall be in gallons.
 13. Connections: Flanged
 14. Minimum Operating Range:
 - a. 3 NPS 5 - 550 gpm.
 - b. 4 NPS 10 - 1250 gpm.
 15. Maximum Operating Temperature: 150 degree F.
 16. Maximum Operating Pressure: 150 psig..
 17. Accuracy: 1-1/2 percent.
 18. Maximum Counter Reading: 100 million

2.03 PRESSURE GAUGES

- A. Pressure Gauges: ASME B40.100, UL listed, 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: 3-1/2 inch diameter.
 - 3. Mid-Scale Accuracy: $\pm$ Two percent of middle half of full scale range.
 - 4. Scale: Psi.

2.04 PRESSURE GAUGE TAPPINGS

- A. Gauge Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Needle Valve: Stainless Steel, 1/4 inch NPT for minimum 150 psi.
- C. Pressure Snubber: Type 316 stainless steel body, type 316 stainless steel ball and 1/4 inch connections.

2.05 STEM TYPE THERMOMETERS

- A. Thermometers - Adjustable Angle: Red- or blue colored, non-toxic liquid in glass; ASTM E1; lens front tube, engineered plastic case, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
 - 1. Size: 7 inch scale.
 - 2. Tube: Glass with magnifying lense.
 - 3. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in degrees F.
 - 4. Window: Clear heavy glass.
 - 5. Stem: Aluminum of length to suit installation.
 - 6. Connector: 3/4 inches with ASME B1.1 screw threads.
 - 7. Accuracy: 1 percent, perASTM E77.

2.06 THERMOMETER SUPPORTS

- A. Thermowells: Pressure-tight, socket-type fitting made for insertion into pipe tee fittings.
 - 1. Thermowells will be coordinated with the inserted device including bore, length, internal threads, and bushings.
 - 2. Standard: ASME B40.200
 - 3. Material for use in Copper Pipe: CNR or CUNI.
 - 4. Material for use in Steel Pipe: CRES or CSA.
 - 5. Type: Stepped or straight shank as required for inserted device.
 - 6. Internal Threads: ASME B1.1 screw threads sized for the inserted device.
 - 7. External Threads: 1/2 NPS, 3/4 NPS, or 1 NPS (as required for insertion in a pipe fitting), ASME B1.20.1 pipe threads.
 - 8. For insulated pipe, body length or extension shall be as required to extend inserted device beyond exterior diameter of the pipe insulation.
 - 9. Accessories:
 - a. Bushings if required to convert the size of the thermowell's internal screw threads to the size of the inserted device connection.
 - b. Commercially-available heat-transfer paste as recommended by the thermowell manufacturer.

2.07 TEST PLUGS

- A. Test Plug: 1/4 inch or 1/2 inch brass fitting for receiving 1/8 inch outside diameter pressure or temperature probe with two (2) self-closing synthetic rubber cores.
 - 1. Core Material: EPDM (Nordel) core with minimum temperature rating of 275 degrees-F at 500 psig.
 - 2. Threads: ASME B1.20.1 tapered-type.
 - 3. Cap: Brass screw cap with gasket and color-coded restraining strap.
 - 4. For insulated pipes, body length or extension shall be as required to extend plug head beyond exterior diameter of the pipe insulation.

- B. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2 inch diameter pressure gauges, one gauge adapters with 1/8 inch probes, two 1-1/2 inch dial thermometers (One with range from 25 to 125 degrees F and the other with range from 0 to 220 degrees F)..

2.08 SIGHT FLOW INDICATOR

- A. Description: Inline pipe-installed device for visual verification of flow.
- B. Construction: Bronze or stainless-steel body with site glass and flow indicator (ball, flapper, or paddle wheel).
- C. Minimum Pressure Rating: 125 psig.
- D. Minimum Temperature Rating: 200 degrees F.
- E. End Connections: Threaded.

PART 3 EXECUTION

3.01 INSTALLATION

- A. General:
 - 1. Install all devices in accordance with manufacturer's recommendations.
 - 2. Install devices in locations where they are easily read from normal operating level.
 - 3. Install all devices where detailed, shown on the floor plans, and/or as specified. No one portion of the plumbing documents takes precedents over another portion.
- B. Water meter.
 - 1. Comply with the requirements of AWWA M6.
 - 2. Minimum meter assemblage requirements shall consist of an inlet shut-off valve, union (if screwed pipe), inlet piece of straight pipe, meter, outlet piece of straight pipe, 1/2 NPS drain valve with male hose connection, and outlet shut-off valve.
 - 3. Length of inlet and outlet straight pipe shall be in accordance with the manufacturer's requirements to insure meter accuracy.
 - 4. Install in the following pipe locations:
 - a. HVAC hydronic system make-up water.
 - b. Cooling tower make-up water.
 - c. Domestic cold water for tenants or other uses inside the building.
 - d. Cold condensate return for cooling tower make-up water.
- C. Pressure gauges and tapings.
 - 1. Install in piping tees or threadolets on larger steel pipe.
 - a. Factory-installed ports on system components may be used if they are suitable.
 - 2. Install each gauge with:
 - a. Pressure snubbers on the inlet of each gauge.
 - b. Dedicated shut-off valve (gauge cock or needle valve) located beyond exterior diameter of any pipe insulation.
 - 3. Install with face vertical to 45 degrees off vertical.
 - 4. Domestic water systems: Install in the following pipe locations:
 - a. After all components of the building's domestic water service entrance.
 - b. Outlet of all pressure regulating valves.
 - c. Discharge of each domestic water booster pump if not an integral part of the booster pump package.
 - 5. Compressed Air Systems: Install in the following locations:
 - a. One located on the discharge pipe after all components of the compressor system including dryers, storage tan, and filters.
 - b. Outlet of all pressure regulating valves.
 - c. At all connections to ewquipment without an associated pressure regulating valve.
- D. Thermowells.
 - 1. Install wells:
 - a. Perpendicular to the pipe in piping tees or threadolets on larger steel pipe.
 - b. Extending 1/3 to 1/2 the way into the interior free area of the pipe.

2. Internal sized as required to match connector of inserted device. Install bushings as required.
 3. Install for:
 - a. All direct-mounted thermometers.
 - b. Permanent temperature sensors as required for the Building Management System (BMS) provided under Division 23.
 4. Coat inserted device's stem with heat-transfer paste before inserting into the thermowell.
- E. Thermometers.
1. Install in thermowells.
 2. Install with face vertical to 45 degrees off vertical.
 3. Install in the following pipe locations:
 - a. Outlet of each domestic water heater without an integral digital readout showing outlet temperature.
 - b. Outlet of each domestic hot water storage tank.
 - c. Outlet of each central thermostatic mixing valve serving multiple fixtures, if not provided as an integral part of the mixing valve.
 - d. Outlet on the domestic water side of a domestic water heat exchanger.
- F. Test (P/T) plugs.
1. Install perpendicular to the pipe in piping tees or threadollets on larger steel pipe.
 - a. Certain devices may have factory-installed ports that may be used (if suitable) for test plug installation.
 2. Install at the most accessible position from the floor as possible.
 3. Domestic Water Systems: Install in the following pipe locations. The downstream plug of one device may be used as the upstream plug of an immediately adjoining device.
 - a. Main water service entrance into the building prior to strainer/backflow preventer assembly.
 - b. Inlet and outlet of each strainer or device with an integral strainer.
 - c. Inlet of each pressure reducing valve.
 - d. Inlet of each domestic water or booster heater.
 - e. Outlet of each domestic water heater with an integral digital readout showing outlet temperature.
 - f. Inlet on the domestic water side of a domestic water heat exchanger.
 - g. Inlet of each domestic hot water storage tank.
 - h. Suction of each domestic water booster pump.
 - i. Suction and discharge of each domestic hot water circulation pump.
 - j. Inlet and outlet of each hot water circulation balancing valve, if not an integral part of the valve.
 4. Compressed Air Systems: Install in the following pipe locations:
 - a. Between each component (compressor, storage tank, filters, dryers) of a non-skid mounted compressor system.
- G. Sight flow indicators:
1. Install in hot water circulating balance valve assemblies.

3.02 ADJUSTING

- A. Clean windows and lenses.
- B. Adjust faces of pressure gauges and thermometers to proper angles for best visibility.
- C. Calibrate pressure gauges to zero.

3.03 SCHEDULES

- A. Pressure Gauges, Scale Range:
 1. Domestic water piping, 0 to 160 psi.
 2. Compressed air: General service, low pressure, 0 to 200 psi.
 3. Backflow preventers, 0 to 160 psi.
- B. Stem Type Thermometers, Scale Range:

1. Domestic hot water, 0 to 250 degrees F.
2. Domestic hot water supply and recirculation, 0 to 250 degrees F.

END OF SECTION

SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Applications. Valves in this section are for the following plumbing systems.
 - 1. Domestic water.
- B. General requirements.
- C. Ball valves.
- D. Butterfly valves.
- E. Check valves.

1.02 ABBREVIATIONS AND ACRONYMS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene-propylene diene monomer synthetic rubber.
- C. NRS: Non-rising stem.
- D. PTFE: Polytetrafluoroethylene synthetic rubber.
- E. SWP: Steam working pressure.
- F. TFE: Tetrafluoroethylene synthetic rubber.

1.03 REFERENCE STANDARDS

- A. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250 2015.
- B. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard 2020.
- C. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves 2022.
- D. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2021.
- E. ASME B16.34 - Valves — Flanged, Threaded, and Welding End 2020.
- F. ASME B31.9 - Building Services Piping 2020.
- G. ASME BPVC-IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators - Welding Brazing and Fusing Qualifications 2019.
- H. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings 2004 (Reapproved 2019).
- 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. MSS SP-45 - Drain and Bypass Connections 2020.
- L. MSS SP-67 - Butterfly Valves 2022.
- M. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends 2018.
- N. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves 2019.
- O. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends 2010, with Errata .
- P. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- Q. NSF 372 - Drinking Water System Components - Lead Content 2022.

1.04 SUBMITTALS

- A. Product Data:
 - 1. Manufacturers catalog information.

2. Performance ratings, rough-in details, weights, support requirements, and piping connections.
 3. Domestic water valves shall state that their wetted surface components are lead-free and de-zincification resistant.
- 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 an approved copy of this submittal, manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.05 QUALITY ASSURANCE

- A. Manufacturer:
1. 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.

1.06 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 ball valves to open position.
- B. Use the following precautions during storage:
1. Maintain valve end protection and protect flanges and specialties from dirt.
 - a. Provide temporary inlet and outlet caps.
 - b. Maintain caps in place until installation.
 2. Store valves in shipping containers and maintain in place until installation.
 - a. Store valves indoors in dry environment.
 - b. Store valves off the ground in watertight enclosures when indoor storage is not an option.

1.07 EXERCISE THE FOLLOWING PRECAUTIONS FOR HANDLING:

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

PART 2 PRODUCTS

2.01 APPLICATIONS

- A. Provide the following valves for the applications:
1. Shutoff: Ball or butterfly.
 2. Dead-End: Single-flange butterfly (lug) type.
 3. Throttling: Provide globe or butterfly.
- B. Substitutions of valves with higher CWP classes or SWP ratings for same valve types are permitted when specified CWP ratings or SWP classes are not available.
- C. Required Valve End Connections for Non-Wafer Types:
1. Copper Tube:
 - a. 2 NPS and Smaller: Solder-joint ends.
 - b. 2-1/2 NPS to 4 NPS: Solder-joint or flanged ends.
- D. Domestic, Hot and Cold Water Valves:
1. 2 NPS and Smaller:
 - a. Bronze Ball: Two piece, full port with brass trim.
 - b. Bronze Swing Check: Class 125, bronze disc.
 2. 2-1/2 NPS and Larger:
 - a. Bronze Ball: Two piece, full port with bronze trim

- b. Iron Single-Flange Butterfly: 200 CWP, EPDM seat, aluminum-bronze disc.
- c. Iron Swing Check: Class 125, metal seats.

2.02 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- B. Valve Sizes: Match upstream piping unless otherwise indicated.
- C. Valves in Insulated Piping: With stem extensions (length as required to clear installed insulation) and the following features:
 - 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.
 - 3. Memory Stops: Fully adjustable after insulation is installed.
- D. Valve-End Connections:
 - 1. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
 - 2. Pipe Flanges and Flanged Fittings 1/2 NPS through 24 NPS: ASME B16.5.
 - 3. Solder Joint Connections: ASME B16.18.
- E. General ASME Compliance:
 - 1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
 - 2. Solder-joint Connections: ASME B16.18.
 - 3. Building Services Piping Valves: ASME B31.9.
- F. Valves for domestic water installation shall have wetted surface components that:
 - 1. Are lead-free in compliance with NSF 61 and NSF 372.
 - 2. Utilize copper alloys that are de-zincification resistant (as defined as containing no more than 15% zinc) and contain additional elements that deter de-zincification.
- G. Valve Bypass and Drain Connections: MSS SP-45.
- H. Source Limitations: Obtain each valve type from a single manufacturer through a single source.

2.03 BRONZE BALL VALVES

- A. One Piece, Reduced Port with Bronze Trim:
- B. Two Piece, Full Port with Bronze Trim:
 - 1. Comply with MSS SP-110.
 - 2. SWP Rating: 150 psig.
 - 3. CWP Rating: 600 psig.
 - 4. Body: Bronze.
 - 5. Ends: As hereinbefore specified for service.
 - 6. Seats: PTFE or TFE.
 - 7. Stem: Bronze.
 - 8. Ball: Chrome plated brass or stainless steel.

2.04 IRON, SINGLE FLANGE BUTTERFLY VALVES

- A. Lug type: Bi-directional dead-end service at rated pressure without use of downstream flange.
 - 1. Comply with MSS SP-67, Type I.
 - 2. CWP Rating: 200 psig.
 - 3. Body: ASTM A126, cast iron or ASTM A536, ductile iron.
 - 4. Stem: One or two-piece stainless steel.
 - 5. Seat: EPDM.
 - 6. Disc: Aluminum-bronze.

2.05 BRONZE SWING CHECK VALVES

- A. Class 125: CWP Rating: 200 psig (1380 kPa).
 - 1. Comply with MSS SP-80, Type 3.

2. Design: Horizontal flow.
3. Body: Bronze, ASTM B62.
4. Ends: As hereinbefore specified for service.
5. Disc: Bronze.

2.06 IRON SWING CHECK VALVES

- A. Class 125:
 1. Comply with MSS SP-71, Type I.
 2. CWP Rating: 200 psig.
 3. Design: Clear or full waterway.
 4. Body: ASTM A126, gray iron with bolted bonnet.
 5. Ends: Flanged.
 6. Trim: Bronze.
 7. Seat Ring and Disc Holder: Bronze.
 8. Gasket: Asbestos free.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

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

END OF SECTION

SECTION 22 05 29
HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Support and attachment components for equipment, piping, and other plumbing work.

1.02 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 portions of the project 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, conduit, cable tray and other potential conflicts (including but not limited to maintenance or operational access or pull-space, equipment removal space, and Code-mandated clearance for electrical access) installed under this Project or that is existing-to-remain.
 - 5. Notify Architect of any conflicts with or deviations from the Contract Documents. Provide a proposed solution. 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 3.

1.03 SUBMITTALS

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

1.04 QUALITY ASSURANCE

- 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 Division 5.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.05 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Comply with MSS SP-58.

2. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
 3. Provide products listed, classified, and labeled as suitable for the 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 the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
 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. Metal Channel (Strut) Framing Systems:
1. Comply with MFMA-4.
- C. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
- D. Thermal Insulated Pipe Supports:
1. General Construction and Requirements:
 - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
 - b. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
 - c. Pipe supports to be provided for nominally sized, 1/2 inch to 30 inch iron pipes.
 - d. Insulation inserts to consist of rigid phenolic foam insulation surrounded by a 360 degree, galvanized steel jacketing.
- E. Pipe Supports:
1. Liquid Temperatures Up To 122 degrees F:
 - a. Overhead Support: MSS SP-58 Types 1, 3 through 12.
 - b. Support From Below: MSS SP-58 Types 35 through 38.
- F. Beam Clamps: MSS SP-58 Types 19 through 23, 25 or 27 through 30 based on required load.
1. Material: ASTM A36/A36M carbon steel or ASTM A181/A181M forged steel.
 2. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- G. Riser Clamps:
- H. Strut Clamps: Two-piece pipe clamp.
- I. Pipe Hangers: For a given pipe run use hangers of the same type and material.
1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 2. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
- J. Intermediate Pipe Guides: Use pipe clamps with oversize pipe sleeve that provides clearance around pipe.
1. Pipe Diameter 6 inches and Smaller: Provide minimum clearance of 0.16 inch.
 2. Pipe Diameter 8 inches: Provide U-bolts with double nuts providing minimum clearance of 0.28 inch.
 3. Pipe Diameter 8 inches: 0.625 inch U-bolt.
 4. Pipe Diameter 10 inches: 0.75 inch U-bolt.
 5. Pipe Diameter 12 to 16 inches: 0.875 inch U-bolt.
 6. Pipe Diameter 18 to 30 inches: 1 inch U-bolt.
- K. Pipe Alignment Guides: Galvanized steel.
1. Pipe Diameter 8 inches and Smaller: Spider or sleeve type.
 2. Pipe Diameter 10 inches and Larger: Roller type.

- L. 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.
- M. Non-Penetrating Rooftop Supports for Low-Slope Roofs:
 - 1. Provide steel pedestals with thermoplastic or rubber base 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.
 - 2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - 3. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
 - 4. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
- N. Anchors and Fasteners:
 - 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

PART 3 EXECUTION

3.01 INSTALLATION

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

END OF SECTION

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SECTION 22 05 53
IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Warning tags.
- D. Pipe markers.
- E. Underground pipe markers.

1.02 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials 2017.

1.03 SUBMITTALS

- A. See Division 1 for submittal procedures.
- B. Submit list of wording, symbols, letter size, and color coding for identification.
- C. Include a statement that the submitted identification items conform to ASME A13.1, NFPA 99, and/or CGA C-9, where appropriate, if not included in the manufacturer's standard submittal sheets.
- D. Nameplate Schedule. Listing of all equipment to be labeled with the proposed content of each label.
- E. Valve Chart and Schedule: Submit valve chart and schedule for each piping system, including valve tag number, location, function, and valve manufacturer's name and model number.
- F. Product Data: Provide manufacturers catalog literature for each product required.
- G. Manufacturer's Installation Instructions: Indicate special procedures and installation requirements.
- H. Project Record Documents: Record actual locations of tagged valves.

1.04 COORDINATION

- A. Coordinate with the manufacturer of the pipe markers to confirm that colors specified are in compliance with the latest ASME A13.1, NFPA 99, CGA C-9, or other applicable standard. Note in the submittal any changes and why.
- B. Coordinate with the Architect if any exterior, exposed-to-public view fuel system piping is to be painted any other color besides safety yellow.
- C. Coordinate installation of identifying devices with:
 - 1. Completion of covering and painting of surfaces where devices are to be applied.
 - 2. Location of access panels and doors.
 - 3. Installation of acoustical ceilings and other similar concealment.
 - 4. The Owner's desire to utilize a different labeling system than the drawing's equipment designation.

PART 2 PRODUCTS

2.01 NAMEPLATES

- A. Plastic nameplates.
 - 1. Laminated three-layer, multi-color plastic with engraved letters, minimum 1/8-inch thick, with pre-drilled holes for attachment hardware.
 - 2. Minimum label size: Length and width vary for required label content, but not less than 2-1/2 inches by 3/4 inch.
 - 3. Plastic shall be able to withstand a minimum of 160 degree-F.
 - 4. Minimum background border around lettering: 1/4 inch.

5. Background color: White.
 6. Letter color: Black.
 7. Letter height:
 - a. 1/4 inch if viewing distance is less than 24 inches.
 - b. 1/2 inch for viewing distances up to 72 inches.
 - c. Proportionately larger lettering for greater viewing distances.
 8. Plastic: Comply with ASTM D709.
 9. Mechanical fastener: Stainless-steel, self-tapping screws.
 10. Adhesive: Contact-type permanent adhesive compatible with label material and equipment substrate.
 11. Small equipment attachment hardware: Brass, beaded chain with snap closer and s-hook.
- B. Nameplate content: Drawing's equipment designation or per Owner's provided labeling system.
- C. Nameplate schedule: Include each item of equipment to be labeled tabulated on an 8-1/2 inches by 11 inches bond paper and an editable electronic format. Tabulate: Each equipment identification number as shown on the Construction Documents, associated Owner's provided labeling (if different than the Construction Documents), all associated Construction Documents sheet number(s) where the equipment is indicated (plans, risers, details, schedules, etc.), and associated specification number/title. Include in the Operation & Maintenance manual.

2.02 VALVE IDENTIFICATION TAGS

- A. Metal tags: Cartridge brass, minimum 19 gauge (0.0359-inch) thickness, with smooth edges, black-filled engraved letters, and pre-drilled/stamped hole for attachment hardware.
- B. Valve identification. Upper row with 1/4-inch lettering for piping system abbreviation and lower row with 1/2-inch identification number.
- C. Size: Minimum 1-1/2 inches diameter. 2 inches diameter if required for service identification abbreviations.
- D. Attachment hardware: 4-1/2 inches long, minimum #6 brass beaded chain(s) with locking-link closer and s-hook. Chain shall have a minimum tensile strength of 30 pounds.
- E. Service identification abbreviations:
1. De-ionized water: DIW.
 2. Domestic cold water: DCW.
 3. Domestic hot water: DHW.
 4. Domestic hot water-140: DHW140.
 5. Domestic hot water return: DHWR
 6. Dual Use Medical Vacuum & Waste anaesthetic gas: MV & WAGD
 7. Instrument air: IA.
 8. Medical air: MA.
 9. Medical Vacuum: MV.
 10. Natural gas: NG.
 11. Nitrogen: N.
 12. Nitrous oxide: NO
 13. Non-potable water: NPW.
 14. Oxygen: O.
 15. Reverse-osmosis water: ROW.
 16. Waste anaesthetic gas: WAGD.
- F. Valve Tag Schedule: Include each item of equipment to be labeled tabulated on an 8-1/2 inches by 11 inches bond paper and an editable electronic format. Tabulate: Piping system, system abbreviation (as shown on the valve tag), valve number, location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff, bypass or similar special uses.

2.03 WARNING TAGS

- A. Warning tags with pre-printed headers constructed of heavy-duty cardstock (suitable for writing) with self-laminating 1-mil thick polyester overlay covering both the front and back. Suitable for indoor use.
- B. Size: Minimum 3-1/2 inches wide by 5-1/2 inches tall.
- C. Attachment: Single hole centered in above the pre-printed header with surrounding fiber-patch grommet material for use with 4-1/2 inches long, minimum #6 brass, beaded chain(s) with locking-link closer and s-hook. Chain shall have a minimum tensile strength of 30 pounds.
- D. Caution type: OSHA-compliant, black outlined "CAUTION" header on yellow background.
- E. Danger type: OSHA-compliant, red/black outlined "DANGER" header on white background.

2.04 PIPE MARKERS

- A. General piping markers shall comply with ASME A13.1, .
- B. Medical gas and vacuum markers shall comply with NFPA 99 and/or CGA C-9.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Tape Pipe Markers: Flexible, vinyl film tape with pressure-sensitive adhesive backing and printed markings. Install with associated pressure-sensitive adhesive arrow tape around the pipe's circumference to indicate direction of flow. Background and arrow colors for arrow tape shall match printed marker.
- E. Markers used on exterior pipe shall be UV resistant.
- F. General piping: Required text and color code for services as follows:

<u>TEXT</u>	<u>BACKGROUND COLOR</u>	<u>LETTERING COLOR</u>
DE-IONIZED WATER	Green	White
DOMESTIC COLD WATER	Green	White
DOMESTIC HOT WATER	Green	White
DOMESTIC HOT WATER-140F	Green	White
DOMESTIC HOT WATER RETURN	Green	White
NATURAL GAS	Yellow	Black
NON-POTABLE WATER	Grey	White
REVERSE OSMOSIS WATER	Green	White
PRIMARY STORMWATER	Green	White
SECONDARY STORMWATER	Green	White

- G. Medical gas and vacuum piping: Required text and color code for services as follows.

<u>TEXT</u>	<u>BACKGROUND COLOR</u>	<u>LETTERING COLOR</u>
INSTRUMENT AIR	Red	White
MEDICAL AIR	Yellow	Black
MEDICAL VACUUM	White	Black
NITROGEN	Black	White
NITROUS OXIDE	Blue	White
OXYGEN	Green	White
WASTE ANAESTHETIC	Violet	White

- 1. Where positive pressure gas piping systems operate at pressures other than the stated pressures below (NFPA 99, Table 5.1.11), the operating pressure shall be included along with the name of the gas on the pipe marker.
 - a. Medical air, nitrous oxide, & oxygen: 50 - 55 psi.
 - b. Instrument air: 80 - 100 psi.
 - c. Nitrogen: 160 - 185 psi.

- d. Medical vacuum & WAGD: 19" in. Hg.
- H. Letter size for outside diameter (OD) of bare or insulation pipes.
 - 1. 3/4 thru 1-1/4 inches OD: 1/2 inch tall.
 - 2. 1-1/2 thru 2 inches OD: 3/4 inches tall.
 - 3. 2-1/2 thru 6 inches OD: 1-1/4 inches tall.
 - 4. 8 thru 10 inches OD: 2-1/2 inches tall.
 - 5. 12 inches and larger OD: 3-1/2 inches tall.

2.05 UNDERGROUND PIPE MARKER TAPE

- A. Non-detectable tape: Bright colored, minimum 4-mil thick polyethylene marking tape shall be a minimum of 6 inches wide with continuous printed black letters on American Public Works Association (APWA) approved colors. Tape shall be specifically designed for direct-buried service, to resist underground elements, and to not turn black over time.
- B. Detectable tape. Bright colored, minimum 5-mil thick polyethylene marking tape with aluminum backing shall be a minimum of 6 inches wide with continuous printed black letters on American Public Works Association (APWA) approved colors. Tape shall be specifically designed to be detected by a metal detector, for direct-buried service, to resist underground elements, and to not turn black over time.
- C. Tape shall state warning and type of service pipe buried below as follows.
 - 1. Domestic water service: "CAUTION BURIED WATER LINE BELOW".
 - 2. Natural or propane gas: "CAUTION BURIED GAS LINE BELOW".
 - 3. Sanitary sewer: "CAUTION BURIED SEWER LINE BELOW"
 - 4. Storm water: "CAUTION BURIED PIPE LINE BELOW".

PART 3 EXECUTION

3.01 PREPARATION

- A. Thoroughly degrease and clean pipe and equipment surfaces to receive adhesive for identification materials.

3.02 NAMEPLATE INSTALLATION

- A. Install permanent nameplates on all equipment shown, scheduled, noted, detailed, or specified in the Plumbing Documents.
- B. Locate nameplates where accessible, visible, and that does not cover equipment information labeling.
- C. Install nameplates with corrosive-resistant mechanical fasteners or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- D. For smaller equipment that does not have sufficient area to mount a nameplate, hang the nameplate on or directly next to the equipment with corrosion resistant chain and s-hooks.

3.03 VALVE IDENTIFICATION TAG INSTALLATION

- A. Install tags on any in-line shut-off, balancing, or flow control valves with beaded chain (multiple if needed for larger components) and s-hooks. Chain shall be installed around valve stem or bonnet.
- B. Tags are not required for check valves, directly-adjacent equipment isolation valves, or individual plumbing fixture stop valves.
- C. Thermostatic mixing valves shall utilize a nameplate.

3.04 WARNING TAG INSTALLATION

- A. Utilize label maker to create required message, professionally stick the message onto the tag below header, and affix the self-laminating overlay covering over the tag.
- B. Attach warning tag to equipment and other plumbing components as required.
- C. Medical gas and vacuum piping requirements:
 - 1. Shutoff valves: Utilize a "Caution" warning tag with the following message.

- a. Name of the specific medical gas or vacuum system. Where positive pressure gas piping systems operate at pressures other than the stated pressures below (NFPA 99, Table 5.1.11), the operating pressure shall be included along with the name of the gas on the warning tag.
 - 1) Medical air, nitrous oxide, & oxygen: 50 - 55 psi.
 - 2) Dental air, Instrument air, & nitrogen: 160 - 185 psi.
- b. Rooms or areas served.
- c. Warning in all capital letters: "DO NOT (Insert OPEN if normally closed or CLOSED if normally open) EXCEPT IN EMERGENCY."
2. Mail line valves: Utilize a "Caution" warning tag with the following message in all capital letters: "MAIN LINE VALVE FOR THE (Insert gas/vacuum system name) SERVING (Insert name of the building)."
3. Riser valves: Utilize a "Caution" warning tag with the following message in all capital letters: "RISER FOR THE (Insert gas/vacuum system name) SERVING (Insert name of the area/building served by the particular riser)."
4. Service valves: Utilize a "Caution" warning tag with the following message in all capital letters: "SERVICE VALVE FOR THE (Insert gas/vacuum system name) SERVING (Insert name of the rooms/area/building served by the particular valve)."

3.05 PIPE MARKER INSTALLATION - ABOVE GRADE

- A. Install pipe markers in accordance with manufacturer's instructions
- B. Do not install pipe markers until painting of the pipe, for either aesthetics or identification, has been completed and dry.
- C. Locate pipe markers where piping is:
 1. Exposed or above accessible ceilings.
 2. Located in accessible maintenance spaces such as chases, shafts, tunnels and plenums.
 3. Exposed exterior areas.
- D. All pipe markers shall be visible from the floor at the point of normal approach.
- E. General piping shall be marked:
 1. At maximum intervals of 20 feet along each run.
 - a. Exception: Non-potable water - maximum interval of 5 feet.
 2. At each branch pipe takeoff or connection.
 - a. Exception: Not required for short branch takeoffs to individual plumbing fixtures when the marker on the main pipe is clearly visible from the branch. Flow direction for branches without pipe markers shall be installed if the flow pattern is not obvious
 3. On both sides at all changes in direction.
 4. On both sides of pipe through penetrations of all walls, partitions, floors, floor/ceiling assemblies, roof, and roof/ceiling assemblies.
 5. Where pipes penetrate into or out of normally-inaccessible chases, shafts, tunnels and plenums.
 6. Where concealed piping is viewable from access doors, manholes, or other access devices.
 7. At each inline valve or control device.
 8. At each connection point to equipment or other points of origination or termination.
- F. Medical gas and vacuum piping shall be marked the same as general piping with the following changes or additions.
 1. At maximum intervals of 20 feet along each run.
 2. At least once in or above every room, even if located above a hard, inaccessible ceiling.
 3. At least once in every story height traversed by a riser, even if located behind hard, inaccessible construction..

3.06 UNDERGROUND PIPE MARKER INSTALLATION

- A. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

- B. Utilize non-detectable tape above metallic pipe and detectable tape above non-metallic pipe.

3.07 PIPE IDENTIFICATION PAINTING

- A. Coordinate the following requirements with the work being performed under Division 9 - Finishes.
- B. Fuel system piping in the following locations shall be painted safety yellow.
 - 1. Mechanical rooms or other non-public spaces where piping is exposed.
 - 2. Exposed in food preparation kitchens with FDA approved epoxy paint.
 - 3. Exposed on the roof not within the public view.
- C. Exterior fuel system piping exposed-to-public view shall be painted safety yellow unless directed differently by the Architect.
- D. Medical gas piping shall not be painted per NFPA 99.

END OF SECTION

**SECTION 22 07 19
PLUMBING PIPING INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Insulation material and accessories:
 - 1. Glass fiber.
 - a. Insulation.
 - b. Factory-installed jacket.
 - c. Accessories
 - 1) Adhesive.
 - 2) Sealant.
 - 3) Mastic.
 - 4) Tape.
 - 5) Field-applied fitting covers.
- B. Jackets and accessories.
 - 1. ASJ.
 - 2. PVC system.
 - a. Pipe jacket.
 - b. Fitting covers.
 - c. Tape.
 - d. Sealant.
 - e. Pipe hanger cover.

1.02 ABBREVIATIONS & DEFINITIONS

- A. Ambient: Immediately surrounding.
- B. Above ambient services: Systems whose bare pipe surface temperature is above the ambient air dewpoint temperature where condensate will not occur on the exterior of the pipe.
- C. Below ambient services: Systems whose bare pipe surface temperature may be below the ambient air dewpoint temperature where condensate will occur on the exterior of the pipe.
- D. EPDM: Ethylene propylene diene monomer.
- E. FDA: Food and Drug Administration.
- F. g/l: Grams per liter.
- G. Joints: Circumferential breaks along the length of the insulation or jacket.
- H. MICA: Midwest Insulation Contractor's Association.
- I. NAIMA: North American Insulation Manufacturer's Association.
- J. PVC: Polyvinylchloride.
- K. OID: Outside insulation diameter.
- L. Seams: Longitudinal breaks along the length of the insulation or jacket.
- M. VOC: Volatile organic compound.

1.03 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- B. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation 2022a.
- C. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel 2008 (Reapproved 2018).
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.

- E. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials 2022a.
- F. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Division 1 for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Surface burning characteristics for insulation material and accessories: Flame spread index/smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.
- B. Insulation material.
 - 1. Shall be manufactured without the use of chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), polybrominated dipheyl ethers (PBDEs), asbestos, or formaldehyde.
- C. Accessories for insulation or jackets.
 - 1. Utilized as recommended by the manufacturer.
 - 2. Compatible with the material on which it will be installed. It shall not soften, corrode, or otherwise attack the insulation or jacket in either the accessory's wet or dry state.
 - 3. Suitable for the intended services' operating temperature.
 - 4. Products applied to exposed surfaces shall be white and suitable for painting.
 - 5. VOC content shall be calculated according to 40 CFR59, Subpart D (EPA Method 24).
 - 6. Adhesive and sealants shall comply with the testing and product requirements of the California Department of Health Services "Standard Practice for the Testing of Volatile Organic Emmissions from Various Sources Using Small-Scale Environmental Chambers".

2.02 GLASS FIBER

- A. Manufacturers:
 - 1. CertainTeed Corporation.
 - 2. Johns Manville Corporation.
 - 3. Knauf Insulation.
 - 4. Owens Corning Corporation.
- B. Pre-formed pipe insulation: ASTM C547 and ASTM C795; Type 1, Grade A, rigid molded, noncombustible type bonded with thermosetting resin.

1. K value: ASTM C177, ≤ 0.24 at 75 degrees F .
 2. Service temperature: ≥ 850 degrees F.
 3. Water-vapor permeability: ≤ 0.02 perm-inches with factory-installed jacket.
 4. Density: ≥ 3.5 pcf.
 5. Factory-installed jacket: ASJ-SSL.
- C. Flexible blanket insulation: ASTM C553 Type V; flexible, noncombustible bonded with thermosetting resin.
1. K value: ASTM C177, ≤ 0.22 at 75 degrees F.
 2. Service temperature: ≥ 850 degrees F.
 3. Water-vapor permeability: ≤ 0.40 perm-inches.
 4. Density: ≤ 2.5 pcf.
 5. Factory-installed jacket: None.
- D. All service jacket (ASJ):
1. White and suitable for painting.
 2. Kraft paper with glass fiber yarn, bonded to aluminized film; maximum moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
 3. Self-sealing lap seams (SSL): Self-sealing, pressure-sensitive, acrylic-based adhesive seams complying with ASTM C1136, Type 1. Adhesive will be protected prior to installation with a removable strip.
- E. Adhesives: For interior applications, VOC content ≤ 80 g/l.
- F. Mastics
1. For interior applications, VOC content < 50 g/l.
 2. Vapor-barrier type - Interior: White, water-based suitable for use on below-ambient services with a water-vapor permeance ≤ 0.013 at 35-mil dry film thickness when tested in accordance with ASTM E96, Procedure B.
 3. Breather type: White, water-based suitable for use on above-ambient services with a maximum water-vapor permeance of 0.0625-mil dry film thickness when tested in accordance with ASTM F1249.
- G. ASJ sealant:
1. For interior applications, VOC content < 420 g/l.
 2. White, fire/water-resistant, flexible type.
- H. ASJ tape: ASTM C1136, white, vapor-retarder type matching the factory-applied ASJ with pressure-sensitive acrylic adhesive protected by a removable liner.
1. Width: ≥ 3 inches.
 2. Thickness: ≥ 10.7 mils.
 3. Water-vapor permeability: < 0.02 perm-in when tested to ASTM E96, Procedure A.
 4. Tensile strength: ≥ 40 lbf/in.
- I. Field-applied, pre-shaped fitting covers.
1. Material: Impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C. Roll-stock ready for shop or field cutting/forming.
 2. Material thickness: ≥ 10 mils.
 3. Color: White.
 4. Shapes: 45- and 90-degree long and short radius elbows, tees, valves, flanges, unions, reducers, end caps, and mechanical joints.
 5. Closure tacks: White-painted, stainless-steel tacks with serrated ribs.
 6. Sealant: Solvent welding adhesive.
 - 7.

2.03 FIELD-APPLIED JACKETS

- A. ASJ: Material shall match factory-applied ASJ on glass fiber insulation.
- B. PVC system

1. Manufacturers:
 - a. Johns Manville Corp.
 - b. Proto Engineered Thermoplastic Corp.
 - c. Shur-Fit Products.
 - d. Speedline Corp.
2. Pipe jacket.
 - a. Material: Impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C. Roll stock ready for shop or field cutting and forming.
 - b. Service Temperature: ≥ 150 degrees F.
 - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 30 mil.
 - e. Color: White.
3. Fitting covers:
 - a. One-piece, factory-fabricated covers of the same material and color as the pipe jacket.
 - b. Shapes: 45- and 90-degree long and short radius elbows, tees, valves, flanges, unions, reducers, end caps, and mechanical joints.
4. Tape: White, vapor-retarder tape compatible with PVC jacket/fittings with pressure-sensitive acrylic adhesive. Nominal 2 inches wide.
5. Sealant: Manufacturer's recommended solvent welding system.
 - a. Jacket may have a factory-installed, self-sealing, pressure-sensitive adhesive strip for the seams in lieu of using the specified adhesive. Not allowed for use in food preparation areas.

PART 3 EXECUTION

3.01 COORDINATION

- A. Prior to pipe installation, coordinate the following:
 1. OID required for sizing pipe hangers, metal protection shields (Type 40), pre-insulated hanger shields (including thickness of insulation for all services and pipe sizes), and sleeves for all services and pipe sizes.
 2. Establish clearance requirements for installation of insulation, jackets, and finishes.
- B. Prior to insulation installation, verify the following before installation of insulation:
 1. That piping has been pressure tested and are free of leaks and physical defects.
 2. That surfaces to be insulated are clean and dry, with foreign material removed.
 3. That all substrates, hangers/supports/shields, sleeves, clearances, and surrounding conditions for compliance with installation tolerances and other conditions affecting the performance of the insulation comply with the requirements for this installation.
 4. That heat tracing that will be covered with insulation has been installed and tested.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.
- D. Application of insulation may begin on those pipe segments that comply with the above requirements.

3.02 INSULATION INSTALLATION - GENERAL REQUIREMENTS

- A. General requirements apply to all insulation material except where more specific requirements are specified, detailed, or noted otherwise in the Plumbing Documents.
- B. Keep insulation dry when stored on site, during installation, and finishing. Wet insulation shall not be installed. Insulation that has gotten wet after installation shall be removed /discarded and new insulation installed at no cost to the Owner.
- C. Insulation and all associated components shall be fabricated, if required, and installed in accordance with the strictest of the following:
 1. Manufacturer's recommendations, guidelines, and instructions.
 2. North American Insulation Manufacturers Association (NAIMA) National Insulation Standards.

3. MICA's "National Commercial & Industrial Insulation Standards, latest edition.
 4. As hereinafter specified.
- D. Install insulation, accessories, and finishes with smooth, straight, and even surfaces. Installation shall be free of voids throughout the length of pipe including fittings, valves, and specialties.
- E. Install insulation over pipe with:
1. Seams on the bottom of horizontal pipes.
 2. Seams at the least visible location on vertical pipes.
 3. The least number of joints practical. Insulate each continuous pipe run with multiple, full-length units of insulation and a single cut piece to complete the run. Do not use multiple cut pieces or scraps.
 4. Tightly closed seams and butted joints.
- F. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other piping specialties (hereinafter referred as fitting insulation) unless otherwise indicated. Fitting insulation shall be of the same insulating material/thickness/density as the adjacent pipe insulation.
1. Utilize pre-formed fitting insulation wherever possible.
 2. Utilize field-or shop-fabricated fitting insulation where pre-formed pipe insulation is not available.
 - a. Create in accordance with industry/municipality's standards utilizing their standard plates or templates.
 - b. Professionally crafted for a high-quality finished appearance.
 - c. Maintain the insulation's vapor barrier where required.
 - d. Fitting insulation created from multiple pieces of pipe or sheet insulation shall be tightly butted and bonded with adhesive to form a single fitting. Types of fabricated fittings are as follow:
 - 1) Mitered fittings created from sections of pre-formed pipe insulation.
 - 2) Factory molded pre-formed pipe insulation.
 - 3) Sectional fittings created from sections of pre-formed pipe insulation.
 - 4) Fittings that utilize sections of oversized pre-formed pipe insulation.
- G. Removable portions of insulation shall be provided where required for routine maintenance.
- H. Below-ambient services' insulation require a vapor barrier.
1. A continuous vapor barrier is required with all seams, joints, and protrusion sealed.
 2. Insulation that requires a vapor barrier shall be continuous and extend thru all hangers, guides, and construction through penetrations.
 - a. Exception: Support components required to be attached directly to the pipe shall be insulated in a similar manner as a fitting to maintain the continuous insulation and vapor barrier, including hanger rods to the structural connection.
- I. Above-ambient services do not require a continuous vapor barrier.
- J. Insulation at pipe hangers/supports.
1. Below-ambient services: Insulation and vapor barrier shall extend through the pipe hanger/support or shall abut the pre-insulated hanger shield.
 2. Above-ambient services: Insulation shall abut to the hanger/support attached directly to the pipe.
- K. Apply adhesives, sealants, and mastics at the manufacturer's recommended coverage rate and wet/dry film thickness.
- L. Adhesives shall be used to bond insulation material to itself or adjoining pieces of similar insulation material to create a single fitting.
- M. Sealants shall be used to close any required protrusions thru the vapor barrier.

3.03 GLASS FIBER ADDITIONAL REQUIREMENTS

- A. Above ambient services:

1. Insulation's ASJ-SSL shall be used to hold the the insulation in place.
2. Joints:
 - a. Concealed: not required to be sealed.
 - b. Exposed: Taped for appearance.
- B. Fitting insulation: Insulate fittings and cover with a pre-shaped PVC fitting cover.
 1. Cover shall be wrapped snugly around the blanket insulation for a continuous, smooth transition to the adjacent insulation's ASJ.
 2. Covers shall overlap adjacent insulation's ASJ.
 3. For below-ambient services, seal seams with solvent welding adhesive. Seal joints to the adjacent insulation's ADJ with PVC tape.
 4. For above-ambient services:
 - a. Concealed: seams may be closed using closure tacks spaced per manufacturer's recommendations (minimum of 2).
 - b. Exposed: Seal in the same manner as below-ambient services.
- C. Mastic: Use to cover any bare insulation.
 1. Below-ambient services: Use vapor-barrier type and flashing sealant.
 2. Above-ambient services: Use breather type.
 3. For fabricated fittings, sections of pre-formed pipe insulation ASJ shall be used to seal any gaps in the ASJ. Mastic shall be appropriate for the service.
- D. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- E. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- F. 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.
 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with PVC fitting covers.

3.04 FIELD-INSTALLED JACKET INSTALLATION

- A. Field-fabricated fitting covers are only allowed if factory-fabricated covers are not made.
- B. Seams and joints
 1. Configured and arranged to shed water.
 2. Staggered away from insulations seams and joints.
 3. Horizontal seams shall be located between the 3 - 4 o'clock or the 8 - 9 o'clock positions with the joint lap pointing downward.
- C. PVC jackets.
 1. Install with minimum 1 inch overlap at seams and joints.
 2. Where solvent-welding adhesive is being used, apply one continuous bead under the lap and another continuous finish bead along the seam edge.
 3. For interior white jackets, seal seams with solvent-welding adhesive and joints with white PVC tape.
 4. Food preparation/service areas (FDA approved system) additional requirements.
 - a. No bare insulation, factory-installed jacket, or mastic-covered insulation can be exposed.
 - b. No bare insulation, factory-installed jacket. or masticSeal all seams and joints with solvent-welding adhesive. Provide a finish continuous bead of of solvent-welding adhesive alon the seam edge if the self-sealing, lap seam is used.
 - c. Any required protrusion thru the jacket shall be closed with sealant.
 - d. Exposed horizontal pipe between OID 2 inches and 8-1/2 inches with exposed clevis hangers (including the threaded rod) shall be covered with a PVC hanger jacket system.
- D. Banding.
 1. At joints of both straight pipe and fittings: Locate bands directly over joints.

2. At seams of straight pipe: Locate bands at maximum 12 inches on-center.
3. Fittings: Number and location of bands shall be in accordance with the manufacturer's recommendations for different pipe sizes and fitting types.
4. Install with manufacturer's recommended tensioner.

3.05 FINISH

- A. Glass fiber with ASJ: Painted as specified in Division 9 for interior painting as directed by the Architect.

3.06 PENETRATIONS

- A. Coordinate installation thru construction penetrations with the type of sleeve and sleeve seal being installed.
- B. For all building construction penetrations with mechanical sleeve seals: Insulation shall firmly butt against botsides of the thermal insulated pipe support.
 1. Glass fiber insulation: Mastic shall be applied to the end of the insulation prior to it being butted against the pipe support.
 - a. Below-ambient services: Vapor barrier type.
 - b. Above-ambient services: Breather type.
- C. For all other building construction penetrations, including fire-rated construction: Insulation shall extend continuously through the construction.

3.07 FIELD QUALITY CONTROL

- A. Testing agency: Owner shall engage a qualified testing agency to perform tests and inspections.
- B. Test and inspections: Inspect pipe, fittings, strainers, and valves (randomly by the Architect) by removing field-applied jacket and insulation in layers in the reverse order of their installation. Extent of inspection shall be limited to the following for each pipe service scheduled hereinafter.
 1. Three locations of straight pipe.
 2. Three locations of threaded, soldered, or pressure-sealed fittings.
 3. Three locations of threaded, soldered, or pressure-sealed strainers.
 4. Three locations of threaded, soldered, or pressure-sealed valves.
 5. Three locations of flanged or grooved fittings.
 6. Three locations of flanged or grooved strainers.
 7. Three locations of flanged or grooved valves.
- C. All insulation applications shall be considered defective if the sample inspections reveals non-compliance with the specification. Refer to Division 1 for "Quality Requirements" for retesting and re-inspecting requirements and "execution" for requirements for correcting the Work.
- D. Re-insulation of compliant inspected locations shall be included as part of the inspection.

3.08 INDOOR PIPE SCHEDULE

- A. Following services shall not be insulated unless noted otherwise in the Plumbing Documents
 1. Waste.
 2. Vent.
 3. Under slab domestic cold water.
 4. Domestic water chrome-plated stop valves and risers at plumbing fixtures.
- B. Acceptable pre-formed pipe, tubular, or sheet insulation material and thicknesses are scheduled on Drawings (see "PLUMBING PIPE INSULATION SCHEDULE") for each piping system and pipe size. If there is more than one type of insulation material listed for a piping system, selection of material to install is at the Contractor's option. All the pipes, no matter the size, for a given system shall be insulated with the same material selected.
- C. Fittings on pipe sized up to 2" shall be mitered. Molded fittings shall be used for 2 ½" and larger. All indoor fitting insulation shall be covered with a tight fitting PVC jacket.
- D. All services listed below are for above slab piping unless noted differently.
- E. Domestic cold water (vapor-barrier required)

- F. Domestic hot and recirculated hot water, 140 degrees-F and lower.
- G. Roof drain bodies, primary and secondary (vapor-barrier required).
- H. Primary and secondary stormwater, above grade, horizontal and vertical, all sizes, (vapor-barrier required).
- I. Primary and secondary stormwater, horizontal at roof level, all sizes (vapor-barrier required).
- J. Condensate (below 60 degrees-F) drain from equipment to termination over drain receptacle, all sizes (vapor-barrier required).

3.09 INDOOR, FIELD-APPLIED JACKETS

- A. Refer to drawings for location, type, and extent of field-installed jackets in addition to the following paragraphs.
- B. Any exposed, insulated, plumbing system pipes in food preparation and serving areas:
 - 1. PVC jacket installed and sealed as required to provide a FDA watertight approved system.

END OF SECTION

**SECTION 22 10 05
PLUMBING PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe, pipe fittings, specialties, and connections for piping systems.
 - 1. Sanitary sewer.
 - 2. Cold condensate from HVAC equipment.
 - 3. Domestic water.
 - 4. Storm water.
 - 5. Natural gas piping.
 - 6. Flanges, unions, and couplings.
 - 7. Pipe hangers and supports.
 - 8. Water pressure reducing valves.
 - 9. Relief valves.
 - 10. Strainers.

1.02 REFERENCE STANDARDS

- A. ANSI Z21.22 - American National Standard for Relief Valves for Hot Water Supply Systems 2015 (Reaffirmed 2020).
- B. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2021.
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2021.
- E. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes 2018.
- F. ASME B31.1 - Power Piping 2022.
- G. ASME B31.9 - Building Services Piping 2020.
- H. ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers 2021.
- I. ASSE 1003 - Performance Requirements for Water Pressure Reducing Valves for Potable Water Distribution Systems 2020.
- 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.
- M. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2022.
- N. ASTM B32 - Standard Specification for Solder Metal 2020.
- O. ASTM B42 - Standard Specification for Seamless Copper Pipe, Standard Sizes 2020.
- P. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- Q. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- R. ASTM B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube 2016.
- S. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings 2016.
- T. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings 2020a.
- U. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems 2020.

- V. ASTM D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings 2020.
- 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 2021.
- Y. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems 2018.
- Z. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings 2017.
- AA. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast 2017, with Errata (2018).
- BB. AWWA C550 - Protective Interior Coatings for Valves and Hydrants 2017.
- CC. AWWA C651 - Disinfecting Water Mains 2014, with Addendum (2020).
- DD. CISPI 301 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications 2021.
- EE. 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.
- FF. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).
- GG. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- HH. NSF 372 - Drinking Water System Components - Lead Content 2022.

1.03 SUBMITTALS

- A. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- B. Shop Drawings: Submit detailed layout developed for this project.
- C. Project Record Documents: Record actual locations of valves.

1.04 QUALITY ASSURANCE

- A. Perform work in accordance with applicable codes.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.

1.05 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.
- 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.

1.06 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

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

2.02 SANITARY SEWER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Epoxy coated Cast Iron Pipe: ASTM A74 service weight.

1. Fittings: Cast iron.
 2. Joints: Hub-and-spigot, CISPI HSN compression type with ASTM C564 neoprene gaskets.
- B. PVC Pipe: Solid wall, ASTM D2665 or ASTM D3034.
1. Fittings: PVC.
 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

2.03 SANITARY SEWER PIPING, ABOVE GRADE

- A. Cast Iron Pipe: CISPI 301, hubless, service weight.
1. Fittings: Cast iron.
 2. Joints: CISPI 310, neoprene gaskets and stainless steel clamp-and-shield assemblies.

2.04 DOMESTIC WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Same pipe as required for the site underground domestic water piping.
- B. Copper Pipe: ASTM B42, annealed.
1. Fittings: ASME B16.26, cast bronze.
 2. Joints: Brazed.
- C. Ductile Iron Pipe: AWWA C151/A21.51.
1. Fittings: Ductile or gray iron, standard thickness.
 2. Joints: AWWA C111/A21.11, styrene butadiene rubber (SBR) or vulcanized SBR gasket with 3/4 inch diameter rods.

2.05 DOMESTIC WATER PIPING, ABOVE GRADE

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), Drawn (H).
1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
 2. Joints: ASTM B32, alloy Sn95 solder.
 3. Mechanical Press Sealed Fittings: Double pressed type, NSF 61 and NSF 372 approved or certified, utilizing EPDM, non toxic synthetic rubber sealing elements.

2.06 STORM WATER PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. PVC Pipe: Solid wall, ASTM D2665 or ASTM D3034.
1. Fittings: PVC.
 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

2.07 STORM WATER PIPING, ABOVE GRADE

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

2.08 NATURAL GAS PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Polyethylene (PE) tubing.
1. Pipe: ASTM D2513, SDR 11, medium density, IPS pressure tubing colored safety yellow.
- B. Steel Pipe: ASTM A53/A53M Schedule 40 black.
1. Fittings: ASTM A234/A234M, wrought steel welding type.
 2. Joints: ASME B31.1, welded.
 3. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

2.09 NATURAL GAS PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M Schedule 40 black steel, Type E or S, Grade B.
1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 2. Joints: Threaded or welded to ASME B31.1.

2.10 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 Inches and Under:
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 Size Over 1 Inch:
 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. Dielectric Connections: Couplings, flanges, or nipples with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.11 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. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
 3. Trapeze Hangers: Welded steel channel frames attached to structure.
 4. Vertical Pipe Support: Steel riser clamp.
 5. Floor Supports: 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/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
 - e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.
- B. Plumbing Piping - Drain, Waste, and Vent:
 1. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
 2. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
 3. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 4. Wall Support for Pipe Sizes 4 Inches 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.
- C. Plumbing Piping - Water:
 1. Hangers for Pipe Sizes 1/2 Inch to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
 2. Hangers for Cold Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
 3. Hangers for Hot Pipe Sizes 2 Inches to 4 Inches: Carbon steel, adjustable, clevis.
 4. Hangers for Hot Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron pipe roll, double hanger.
 5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
 7. Wall Support for Hot Pipe Sizes 6 Inches and Over: 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 Inches: Cast iron adjustable pipe saddle, locknut, nipple, floor flange, and concrete pier or steel support.

10. Floor Support for Hot Pipe Sizes 6 Inches and Over: 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.
- D. Hanger Fasteners: Attach hangers to structure using appropriate fasteners as required and directed by the Structural Engineer.

2.12 WATER PRESSURE REDUCING VALVES

- A. Up to 2 Inches:
1. ASSE 1003, bronze body, stainless steel, and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded single union ends.
- B. Over 2 Inches:
1. ASSE 1003, cast iron body with interior lining complying with AWWA C550, bronze fitted, elastomeric diaphragm and seat disc, flanged.

2.13 RELIEF VALVES

- A. Temperature and Pressure:
1. ANSI Z21.22, AGA certified, bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, temperature relief maximum 210 degrees F, capacity ASME BPVC-IV certified and labelled.

2.14 STRAINERS

- A. Size 2 inch and Under:
1. Threaded brass body for 175 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
 2. Class 150, threaded bronze body 300 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
- B. Size 1-1/2 inch to 4 inch:
1. Class 125, flanged iron body, Y pattern with 1/16 inch stainless steel perforated screen.
- C. Size 5 inch and Larger:
1. Class 125, flanged iron body, basket pattern with 1/8 inch stainless steel perforated screen.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION

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

3.03 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C. 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.
- F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- H. Provide access where valves and fittings are not exposed.

1. Coordinate size and location of access doors.
- I. Establish elevations of buried piping outside the building to ensure not less than 36" of cover.
- J. Install vent piping penetrating roofed areas to maintain integrity of roof assembly.
- 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 ready for finish painting.
- N. Excavate, trenching, and backfilling in accordance with Division 31.
- O. Install bell and spigot pipe with bell end upstream.
- P. Install valves with stems upright or horizontal, not inverted. Refer to Section 22 05 23.
- Q. Install water piping to ASME B31.9.
- R. 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.
- S. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- T. Pipe Hangers and Supports:
 1. Install in accordance with ASME B31.9.
 2. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 3. Place hangers within 12 inches of each horizontal elbow.
 4. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 5. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 7. Provide copper plated hangers and supports for copper piping.
 8. Provide padded hangers for piping that is subject to scratching.
 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.
 10. Provide hangers adjacent to motor driven equipment with vibration isolation.
 11. Support cast iron drainage piping at every joint.
- U. 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.

3.04 APPLICATION

- A. Install unions downstream of valves and at equipment or apparatus connections.
- B. Install gate or ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- C. Install globe valves for throttling, bypass, or manual flow control services.
- D. Provide spring loaded check valves on discharge of water pumps.
- E. Provide flow controls in water recirculating systems where indicated.

3.05 TOLERANCES

- A. Drainage Piping: Establish invert elevations within 1/2 inch vertically of location indicated and slope to drain at minimum of 1/4 inch per foot slope.
- B. Water Piping: Slope at minimum of 1/32 inch per foot and arrange to drain at low points.

3.06 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Disinfect water distribution system in accordance with Division 33.
- 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.
- 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.

3.07 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.
- C. At end of construction and prior to turnover of building to owner, contractor is to run a camera through all sanitary mains (4" and above) included within the scope of the project to the greatest extent of:
 - 1. 10 feet beyond the point of connection of the renovation or construction work;
 - 2. The next pipe size increase;
 - 3. 10 feet outside the building.
- D. Where project includes a connection to sanitary utility, the camera needs to record to that connection point. This recording is to be properly labeled to indicate the position of the camera at various points for reference. This recording is to be turned over to owner at completion of construction but immediately prior to turnover of building.

3.08 SCHEDULES

- A. Pipe Hanger Spacing:
 - 1. Metal Piping:
 - a. Pipe Size: 1/2 inches to 1-1/4 inches:
 - 1) Maximum Hanger Spacing: 6.5 ft.
 - 2) Hanger Rod Diameter: 3/8 inches.
 - b. Pipe Size: 1-1/2 inches to 2 inches:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 3/8 inch.
 - c. Pipe Size: 2-1/2 inches to 3 inches:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 1/2 inch.
 - d. Pipe Size: 4 inches to 6 inches:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 5/8 inch.
 - e. Pipe Size: 8 inches to 12 inches:
 - 1) Maximum hanger spacing: 14 ft.
 - 2) Hanger Rod Diameter: 7/8 inch.
 - f. Pipe Size: 14 inches and Over:
 - 1) Maximum Hanger Spacing: 20 ft.
 - 2) Hanger Rod Diameter: 1 inch.

2. Plastic Piping:
 - a. All Sizes:
 - 1) Maximum Hanger Spacing: 6 ft.
 - 2) Hanger Rod Diameter: 3/8 inch.

END OF SECTION

**SECTION 22 10 06
PLUMBING PIPING SPECIALTIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Drains.
- B. Cleanouts.
- C. Hose bibbs.
- D. Hydrants.
- E. Water valve and recessed supply box.
- F. Backflow preventers.
- G. Double check valve assemblies.
- H. Water hammer arrestors.
- I. Mixing valves.
- J. Fire-rated enclosures.

1.02 REFERENCE STANDARDS

- A. ASME A112.6.4 - Roof, Deck, and Balcony Drains 2022.
- B. ASSE 1011 - Performance Requirements for Hose Connection Vacuum Breakers 2017.
- C. ASSE 1012 - Performance Requirements for Backflow Preventers with an Intermediate Atmospheric Vent 2021.
- D. ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies 2021.
- E. ASSE 1019 - Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance 2011 (Reaffirmed 2016).
- F. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- G. NSF 372 - Drinking Water System Components - Lead Content 2022.
- H. PDI-WH 201 - Water Hammer Arresters 2017.

1.03 SUBMITTALS

- A. Product Data: Provide component sizes, rough-in requirements, service sizes, and finishes.
- B. Shop Drawings: Indicate dimensions, weights, and placement of openings and holes.
- C. Certificates: Certify that grease interceptors meet or exceed specified requirements.
- D. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.
- E. Sustainable Design Documentation: Submit appropriate evidence that materials used in potable water systems comply with the specified requirements.
- F. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- G. Project Record Documents: Record actual locations of equipment, cleanouts, backflow preventers, water hammer arrestors.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

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

2.02 DRAINS

- A. Primary Roof Drains:
 - 1. Assembly: ASME A112.6.4.

2. Body: Lacquered cast iron with sump.
3. Strainer: Removable polyethylene dome with vandal proof screws.
- B. Secondary Roof Drains:
 1. Same as primary roof drain but with 2" internal dam.
- C. Downspout Nozzles:
 1. Bronze body with bronze outlet nozzle, bird screen, and wall flange.
- D. Floor Drains:
 1. ASME A112.6.3. lacquered cast iron body with flange, weep holes, reversible clamping collar, and adjustable strainer.
- E. Floor Sink:
 1. Lacquered cast iron body with dome strainer..

2.03 CLEANOUTS

- A. Cast-iron cleanouts: ASME A112.36.2M

2.04 HOSE BIBBS

- A. Interior Hose Bibbs:
 1. Bronze or brass with integral mounting flange, replaceable hexagonal disc, hose thread spout, chrome plated where exposed with handwheel, integral vacuum breaker in compliance with ASSE 1011.

2.05 HYDRANTS

- A. Wall Hydrants:
 1. ASSE 1019; freeze resistant, self-draining type with chrome plated wall plate hose thread spout, lockshield and removable key, and integral vacuum breaker.

2.06 WATER VALVE AND RECESSED SUPPLY BOX

- A. Description: Preformed rough-in box with brass valves with shutoff, slip in finishing cover.

2.07 BACKFLOW PREVENTERS

- A. Reduced Pressure Backflow Preventers:
 1. ASSE 1013; bronze body with bronze internal parts 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; non-threaded vent outlet; assembled with two gate valves, strainer, and four test cocks.

2.08 DOUBLE CHECK VALVE ASSEMBLIES

- A. Double Check Valve Assemblies:
 1. ASSE 1012; Bronze body with corrosion resistant internal parts and stainless steel springs; two independently operating check valves with intermediate atmospheric vent.

2.09 WATER HAMMER ARRESTORS

- A. Water Hammer Arrestors:
 1. Copper construction, piston type sized in accordance with PDI-WH 201, precharged suitable for operation in temperature range minus 100 to 300 degrees F and maximum 250 psi working pressure.

2.10 MIXING VALVES

- A. Thermostatic Mixing Valves:
 1. Valve: Chrome plated cast brass body, stainless steel or copper alloy bellows, integral temperature adjustment.
 2. Accessories:
 - a. Check valve on inlets.
 - b. Volume control shut-off valve on outlet.
 - c. Stem thermometer on outlet.
 - d. Strainer stop checks on inlets.

2.11 FIRE-RATED ENCLOSURES

- A. Provide as required to preserve fire resistance rating of building elements.

PART 3 EXECUTION

3.01 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.
- 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.
- F. Pipe relief from backflow preventer to nearest drain.
- G. Install water hammer arrestors complete with accessible isolation valve on hot and cold water supply piping to lavatory sinks, washing machine outlets, or other quick closing valves.

END OF SECTION

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**SECTION 22 30 00
PLUMBING EQUIPMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Water Heaters:
 - 1. Commercial gas fired.
- B. Diaphragm-type compression tanks.
- C. Water softeners.
- D. Deionization equipment.
- E. In-line circulator pumps.

1.02 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, with Errata (2020).
- B. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels 2021.

1.03 SUBMITTALS

- A. Product Data:
 - 1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
 - 2. Indicate pump type, capacity, power requirements.
 - 3. Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
 - 4. Provide electrical characteristics and connection requirements.
- B. Project Record Documents: Record actual locations of components.
- C. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- D. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

- A. Certifications:
 - 1. Water Heaters: NSF approved.
 - 2. Gas Water Heaters: Certified by CSA International to ANSI Z21.10.1, as applicable, in addition to requirements specified elsewhere.
 - 3. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.
- B. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.
- C. Performance: Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 WARRANTY

- A. Provide five year manufacturer warranty for domestic water heaters.

PART 2 PRODUCTS

2.01 WATER HEATERS

- A. Commercial Gas Fired:

1. Type: Automatic, natural gas-fired, vertical storage.
2. Tank: Glass lined welded steel ASME labeled; multiple flue passages, 4 inch diameter inspection port, thermally insulated with minimum 2 inches glass fiber, encased in corrosion-resistant steel jacket; baked-on enamel finish; floor shield and legs.
3. Accessories:
 - a. Water Connections: Brass.
 - b. Dip Tube: Brass.
 - c. Drain valve.
 - d. Anode: Magnesium.
 - e. Temperature and Pressure Relief Valve: ASME labeled.
4. Certified For The Following Applications:
 - a. Automatic storage water heater.
 - b. For operation at 180 degrees F.

2.02 DIAPHRAGM-TYPE COMPRESSION TANKS

- A. 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, with flexible EPDM diaphragm sealed into tank, and steel legs or saddles.
- B. Accessories: Pressure gauge and air-charging fitting, tank drain; precharge to 12 psig.

2.03 WATER SOFTENERS

- A. Softener Tank:
 1. Glassfiber reinforced plastic tank.
- B. Brine Tank:
 1. Glassfiber reinforced plastic tank.
- C. Microprocessor Based Control: Brass control valve cycled to regenerate after adjustable metered quantity of water flow.

2.04 DEIONIZATION EQUIPMENT

- A. Refer to Equipment Schedules on Drawings for capacities and equipment requirements.

2.05 IN-LINE CIRCULATOR PUMPS

- A. Casing: Bronze, rated for 125 psig working pressure, with stainless steel rotor assembly.
- B. Impeller: Bronze.
- C. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.
- D. Seal: Carbon rotating against a stationary ceramic seat.
- E. Drive: Flexible coupling.

2.06 ELECTRICAL WORK

- A. Provide electrical motor driven equipment specified complete with motors, motor starters, controls, and wiring.
- B. Electrical characteristics to be as specified or indicated.
- C. Furnish motor starters complete with thermal overload protection and other appurtenances necessary for the motor control specified.
- D. Supply manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices not shown.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install plumbing equipment in accordance with manufacturer's instructions, as required by code, and complying with conditions of certification, if any.
- B. Coordinate with plumbing piping and related fuel piping work to achieve operating system.
- C. 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.
- D. Pumps:
1. 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.
 2. Align and verify alignment of base mounted pumps prior to start-up

END OF SECTION

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**SECTION 22 40 00
PLUMBING FIXTURES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. General requirements.
- B. Regulatory requirements.
- C. ADA/ABA requirements.
- D. Fixture supply fittings.
- E. Fixture waste fittings.
- F. ADA waste/supply fitting protective shielding guards.
- G. Carriers.
- H. Water closets.
 - 1. Flush valve type.
- I. Urinals.
- J. Lavatories.
- K. Sinks.
- L. Laminar-flow spouts for sinks.
- M. Disposers.
- N. Dishwasher air-gap fittings.
- O. Showers.
- P. Electric water coolers.
- Q. Service sinks.
- R. Emergency eyewash

1.02 REFERENCE STANDARDS

- A. ANSI Z358.1 - American National Standard for Emergency Eyewash and Shower Equipment 2014.
- B. ASME A112.18.1 - Plumbing Supply Fittings 2018.
- C. ASME A112.19.2 - Ceramic Plumbing Fixtures 2018, with Errata.
- D. ASME A112.19.3 - Stainless Steel Plumbing Fixtures 2022.
- E. ASSE 1014 - Performance Requirements for Backflow Prevention Devices for Hand-Held Showers 2020.
- F. ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices 2020.
- G. ISFA 2-01 - Classification and Standards for Solid Surfacing Material 2013.
- H. NEMA LD 3 - High-Pressure Decorative Laminates 2005.
- I. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- J. NSF 372 - Drinking Water System Components - Lead Content 2022.
- K. UL (DIR) - Online Certifications Directory Current Edition.

1.03 SUBMITTALS

- A. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- B. Each ADA-designated fixture shall bear the ADA symbol or be so noted for compliance.
- C. Manufacturer's Instructions: Indicate installation methods and procedures.
- 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.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project. Extra material shall match products installed, packaged individually with protective covering, and identified with labels describing content.
 - 1. Extra Faucet Washers and O-rings: Equal to 10 percent of installed but not less than 2 for each type and size.
 - 2. Extra Faucet Cartridges and O-rings: Equal to 5 percent of installed but not less than 2 for each type and size.
 - 3. Extra Toilet Seats: Equal to 5 percent of installed but not less than 1 of each type and size.
 - 4. Flush Valve Service Kits: Equal to 10 percent of installed but not less than 1 for each type and size.

1.04 QUALITY ASSURANCE

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 WARRANTY

- A. See Division 1 for additional warranty requirements.
- B. Provide five year manufacturer warranty for electric water cooler.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Source limitations: Obtain plumbing fixtures and accessories of each category from a single manufacturer from a single source.
 - 1. If a plumbing item is not available from a single manufacturer, obtain a similar product from other manufacturer specified for that category.
- B. Refer to Plumbing Fixture Schedule on Drawings for basis of design manufacturer and model information.
- C. Copper alloy requirements: Copper alloy components in contact with domestic water (wetted surface) shall be de-zincification resistant (DZR). DZR shall be defined as containing no more than 15 percent zinc and containing additional elements that deter the selected leaching of zinc from the alloy.
- D. Lead free requirements: The potable water portion of all plumbing fixtures and accessories that could be used to supply water for human consumption shall comply with NSF 61 and NSF 372 for maximum lead content and be so labelled.
- E. Water Efficiency: EPA WaterSense label is required for all water closets, urinals, lavatory faucets, and showerheads.
- F. Vitreous China: All vitreous ware shall be impervious throughout and of the best of their respective kind. All fixtures shall be white (unless scheduled differently) with a continuous, smooth gloss surface without flaws or cracks.
- G. Fixtures that are wall-hung or abut a wall or surface shall have the abutting edges, surfaces, etc. factory-ground true and square.
- H. All exposed metal fixture trim shall be polished chrome-plated unless noted or scheduled otherwise.
- I. Select combinations of fixture, valves, faucets, trim, fittings, and other components that are compatible and function as a single unit.

- J. Threads:
 - 1. Hose-coupling type: ASME B1.20.7.
 - 2. Pipe type: ASME B1.20.1.

2.02 REGULATORY REQUIREMENTS

- A. Comply with applicable codes for installation of plumbing systems.
- B. Comply with UL (DIR) requirements.
- C. ADA-designated plumbing fixtures and their installation shall comply with the latest version of the "ADA Standards for Accessible Design" as published by the Department of Justice.
- D. ABA-designated plumbing fixtures and installation shall comply with the latest version of the "Architectural Barriers Act (ABA) Standards as adopted by the Department of Defense (DOD), General Services Administration (GSA), and the U.S. Postal Service (USPS).
- E. Perform work in accordance with local health department regulations.

2.03 ADA/ABA REQUIREMENTS

- A. Each ADA-designated fixture shall be provided with all accessories as required for a completely ADA-compliant installation.
- B. Each ABA-designated fixture shall be provided with all accessories as required for a completely ABA-compliant installation.

2.04 FIXTURE SUPPLY FITTINGS

- A. ASME A112.18.1.
- B. Supply stop valves: Surface-mounted valves shall be chrome-plated, solid brass, angle valves with handles and chrome-plated, cast brass, escutheons. Size shall be as scheduled for the fixture. Type of pipe connection to the stop valve shall be coordinated with the type of supply pipe.
 - 1. Dual outlet stop valves with individual handles may be used to serve immediately adjacent equipment.
- C. Supply riser tube: Diameter, length, and connection type shall be coordinated with the fixture.
 - 1. Chrome-plated copper: Bendable, polished chrome-plated copper tube with shaped sealinghead and brass ferrule.
 - 2. Braided, stainless-steel hose: Tubing constructed with a flexible rubber inner core conforming to NSF standards for potable water and an outer covering of braided stainless-steel. Diameter of dual, male, screwed fittings shall be coordinated with the fixture.

2.05 FIXTURE WASTE FITTINGS

- A. ASME A112.18.2.
- B. Brass waste fitting: Chrome-plated cast brass tailpiece, adjustable p-trap with cleanout plug and tubing drain to wall, slip-nuts, and wall escutcheon with set-screw. Inlet and outlet diameter, tailpiece length, and connection to waste pipe riser shall be coordinated with fixture and rough-in connections
 - 1. Lavatory: Minimum 17 gauge tailpiece with chrome-plated cast brass grid strainer.
 - a. If lavatory is specified with a pop-up drain, tailpiece is specified with the faucet.
 - b. ADA-compliance: Utilize a chrome-plated, cast brass 5-1/2 inches offset tailpiece with grid strainer if required by the manufacturer for an ADA-compliant installation.
 - 2. Sink: Minimum 20 gauge tailpiece with forged stainless-steel basket strainer.
 - a. Multiple bowl sink: Provide with one forged stainless-steel basket strainer per bowl. Garbage disposer may replace one strainer as scheduled.
 - b. ADA-compliance: Utilize a chrome-plated, cast brass 5-1/2 inches offset tailpiece with forged stainless-steel basket strainer if required by the manufacturer for an ADA-compliant installation.

2.06 ADA WASTE/SUPPLY FITTING PROTECTIVE SHIELDING GUARDS

- A. ASME A112.18.9.
- B. Exposed waste/supply piping cover kit:
 - 1. Kit shall include individual pieces to cover the exposed waste pipe from the wall penetration to the fixture waste connection (including an offset grid strainer if required), cold water supply fitting/riser from the wall penetration to the faucet connection, and hot water supply fitting/riser from the wall penetration to the faucet connection.
 - 2. Construction: Minimum 1/8 inch thick molded, closed-cell vinyl with concealed nylon fasteners.
 - 3. Color: White.
- C. Countertop lavatory/sink pipe enclosure:
 - 1. Sink coordination: Use with an ADA-compliant sink or lavatory with a maximum 6 inch deep bowl and rear waste outlet.
 - 2. Enclosure: 36 inches or 42 inches wide (can be trimmed to fit) and shaped to maintain the ADA-mandated wheelchair-accessible knee and foot clearance. Bottom edge is strengthened by the use of PVC rolled reinforcement.
 - 3. Construction: Minimum 0.093 inch thick impact/stain/chemical resistant molded, rigid, vinyl material.
 - 4. Side wall or cabinet connection: Enclosure uses a pre-shaped, PVC slotted bracket to mount on each sidewall or cabinet to support the sides of the enclosure. Utilize eight (four per side) stainless-steel torx-head screw fasteners (supplied with enclosure).
 - 5. Color: China white or beige fine haircell finish. White finish is suitable for painting with either acrylic enamel or latex.

2.07 CARRIERS

- A. ASME A112.6.1M.
- B. Water closet carriers.
 - 1. Delegated-design: Contractor shall select water closet carriers of a type/design required by the attached fixture with consideration for space limitations, fixture mounting height (standard or ADA-compliant), type of piping connections, piping flow arrangement, and arrangement/location of adjoining fixtures to provide proper waste pipe slope.
 - 2. Construction: Cast iron (Gray, A4B, Class 35) frame coated with latex-based paint, integral drain hub and vent pipe connections, faceplate, adjustable gasketed coupling, lugs for floor attachment, flush valve support, and threaded fixture studs with nuts and washers. Include other manufacturer's options as required for proper system piping and fixture support.
 - 3. Load bearing capacity: Standard - 500 pounds. Bariatric - 1000 pounds.
- C. Urinal carriers: Carbon structural steel (ASTM A500, Grade C) tubularor/rectangular upright legs with welded base feet slotted for anchor bolts. Carrier system includes vertically adjustable lower bearing plate, vertically adjustable upper universal hanger plate, and mounting fasteners & hardware. Upright legs and plates shall be coated with latex-based paint.
- D. Lavatory carriers: Steel tubularor/rectangular upright legs with welded base feet slotted for anchor bolts coated with latex-based paint, cast iron adjustable headers, concealed arams with leveling screws & locking device, steel sleeves, alignment truss, and mounting fasteners.
- E. Sink carriers: Steel tubularor/rectangular upright legs with welded base feet slotted for anchor bolts coated with latex-based paint, adjustable support plate, and mounting hardware.
- F. Electric water cooler carriers: Steel tubularor/rectangular upright legs with welded base feet slotted for anchor bolts coated with latex-based paint, adjustable upper and lower support plates, and mounting hardware.

2.08 FLUSH-VALVE WATER CLOSETS

- A. Water Closets: Vitreous china, ASME A112.19.2, siphon jet flush action with elongated rim.
 - 1. Floor-mounted fixtures: Include closet floor flange, non-corrosive closet bolts/washers/nuts, and plastic bolt cover caps.
 - a. Flush Valve: Exposed (top spud).

- B. Flush Valves: ASME A112.19.5, chrome-plated cast brass construction complete with vacuum breaker stops and accessories.
 - 1. Electrical components for sensor-operated valves: UL 1951.
- C. Seats: ANSI Z124.5, solid white(unless scheduled differently) plastic, open front, extended back, self-sustaining hinge, brass bolts, without cover.

2.09 WALL-HUNG URINALS

- A. Urinals: Vitreous china, ASME A112.19.2, wall hung with side shields and concealed carrier.
 - 1. Flush Valve: Exposed (top spud).
 - 2. Trap: Integral.
- B. Flush Valves: ASME A112.18.1, Chrome-plated cast brass construction complete with vacuum breaker stop and accessories.
 - 1. Electrical components for sensor-operated valves: UL 1951.

2.10 LAVATORIES

- A. Wall-Hung Basin: ASME A112.19.2; vitreous china lavatory with 4 inch high back, rectangular basin with splash lip, front overflow, soap depression, number/spacing of holes to match faucet, and designed to be used with a concealed arm carrier.
- B. Counter Top Basin: ASME A112.19.2; vitreous china self-rimming lavatory, front overflow, soap depression, and number/spacing of holes to match faucet.
- C. Supply Faucet: ASME A112.18.1; chrome-plated (unless scheduled differently) cast brass construction.
 - 1. Electrical components for sensor-operated faucets: UL 1951.
- D. Thermostatic Mixing Valve: Thermostatic mixing valve, ASSE 1070 listed, with combination stop, strainer, and check valves, and flexible stainless steel connectors.
- E. Accessories: Appropriate supply and waste fittings.

2.11 SINKS

- A. Bowl(s): ASME A112.19.3; minimum 20 gage, 0.0359 inch thick, Type 304 stainless steel, self rimming and undercoated with number/spacing of holes drilled to match faucet and trim.
- B. Supply Faucet(s): ASME A112.18.1; chrome-plated (unless scheduled differently) cast brass construction.
- C. Accessories: Appropriate supply and waste fittings.

2.12 LAMINAR FLOW SPOUTS FOR FAUCETS

- A. Chrome-plated brass-construction outlet spouts for faucets that produce non-aerating laminar stream. Male or female thread as required to mate to faucet outlet. Flow rate range shall match flow of faucet.

2.13 DISPOSERS:

- A. ASSE 1008 and UL 430.

2.14 DISHWASHER AIR-GAP FITTING

- A. ASSE 1021, fitting suitable for use with domestic dishwashers (for deck mounting) with plastic body, chrome-plated brass cover.
 - 1. Capacity: Minimum 5 gpm.
 - 2. Inlet pressure: Minimum of 5 psig at a minimum temperature of 140 degrees F.
 - 3. Hose connections: Inlet - 5/8 inch ID, Outlet - Minimum 7/8 inch ID with hose connection.

2.15 SHOWERS

- A. Shower Valve:
 - 1. Comply with ASME A112.18.1.
 - 2. Provide two way in-wall diverter valve body with integral thermostatic mixing valve.
- B. Shower Head: ASME A112.18.1.

C. ADA Hand-Held Shower Head:

1. ASME A112.18.1, adjustable spray hand-held shower head with swivel fitting, with ASSE 1014 backflow preventer.

2.16 ELECTRIC WATER COOLERS

- A. Water Cooler: Electric, mechanically refrigerated; surface-mounted; stainless steel top, vinyl on steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push button(s), mounting bracket; integral air cooled condenser and stainless steel grille.
1. Electrical: 115 V, 60 Hertz compressor, 6 foot cord and plug for connection to electric wiring system including grounding connector.

2.17 SERVICE SINKS

- A. Bowl: ANSI Z124.6, white plastic, floor mounted type with shoulders, vinyl bumper guard, stainless steel strainer.
- B. Trim: ASME A112.18.1 exposed wall type supply with lever handles, spout wall brace, atmospheric vacuum breaker (ASSE 1001), hose end spout, strainers, eccentric adjustable inlets, integral screwdriver stops with covering caps and adjustable threaded wall flanges.
- C. Accessories:
1. 5 feet of 1/2 inch diameter plain end reinforced plastic hose.
 2. Hose clamp hanger.
 3. Mop hanger.

2.18 EMERGENCY EYEWASH

- A. Emergency Wash: ANSI Z358.1; self-cleaning, non-clogging eye and face wash with quick opening, full-flow valves, ABS eye and face wash receptor, twin eye wash heads and face spray ring, stainless steel dust cover, copper alloy control valve and fittings.
- B. Thermostatic Mixing Valve: Thermostatic mixing valve, ASSE 1070 listed, with combination stop, strainer, and check valves, and flexible stainless steel connectors. Preset discharge temperature to 85 degree F.

PART 3 EXECUTION

3.01 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. Notify the Architect before proceeding with any work if a conflict arises with other portions of the Project.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Rough-in fixture piping connections in accordance with minimum sizes indicated in the Plumbing Documents.
- B. Rough-in supply piping in locations that can be easily reached for operation of installed stop valves. Supply pipe shall be rigidly supported within the pipe space behind the fixture. Provide dielectric isolation of any copper pipe to dissimilar metal support.
1. Any fixture that cannot be installed with a wall-mounted or integral stop valve shall be isolated with an in-line ball valve that can be accessed.
- C. Waste and supply connections for fixtures shall be located and installed in a neat and uniform manner and as required for the proper operation and a professionally finished installation of the plumbing fixture.
- D. Connect carrier supports, affixed to building substrate, for all wall-hung fixtures.

3.03 GENERAL INSTALLATION

- A. Prior to installation, inspect all plumbing fixture components for damage or manufacturing defects. Do not install defective fixtures or components.
- B. Assemble plumbing fixtures with all trim, fittings, and other components according to the manufacturer's written instructions.
- C. Install, support, and connect to the required piping systems as indicated in the Plumbing Documents and as required for a properly functioning and professional appearing fixture installation.
- D. Escutcheons: Install escutcheons at all pipe wall/floor/ceiling membrane penetrations, including within cabinets and millwork. Escutcheon shall completely cover the whole in the construction membrane.
- E. Fixture supply fittings. Install stop valve(s) firmly butted tight to the escutcheon. Pipe risers from the stop valve(s) to the fixture including exposed instantaneous water heaters, shall be installed with smooth curves and with minimal slack tubing.
- F. Install each fixture to be directly connected to the waste system with a fixture waste fitting including a trap, located for easy access for cleaning.
- G. Install each fixture to be indirectly connected to the waste system with tubular waste piping, extending from the fixture waste connections and terminated over a drain body with a Code-compliant air gap.
- H. Install plumbing fixtures and components level and plumb.
- I. Set all floor-mounted plumbing fixtures, excluding water closets or other fixture with legs, in a leveling bed of cement grout.
- J. Completely seal joints between plumbing fixtures and adjoining walls/floors/countertops watertight using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to the fixture color. Finish shall be smooth and matching the contour of the plumbing fixture.
- K. Install check valves on water supplies serving janitorial service sinks.
- L. Install a faucet-spout or flow-control fitting on faucet spouts as required to achieve the designated flow rates and patterns.
- M. Connect under-counter dishwashers to the adjoining sink with a dishwasher air-gap fitting. Connect fitting's outlet hose to the sink's disposer.
- N. Install the hot-water dispenser in the pre-punched hole on the back surface of the sink or in the adjoining countertop with the spout over the sink bowl.

3.04 ADA FIXTURE REQUIREMENTS

- A. Fixtures shall be installed within the manufacturer's recommendations and as coordinated with the Architect's documents to insure its compliance with ADA requirements.
- B. Coordinate the installation of ADA water closets with flush valves to insure the mandated clearances with the associated grab bar
- C. Handles for manual flush valves for ADA water closets shall be installed on the wide side of the fixture.
- D. Juvenile ADA fixture installation shall be in accordance with the ADA/ABA guidelines for the age group being served.

3.05 JUNIOR FIXTURE INSTALLATION

- A. Junior wall-hung lavatory or washfountains: Set top of rim 238" above finish floor.

3.06 EMERGENCY EYEWASH/SHOWER INSTALLATION

- A. Completed installation shall conform to all of the requirements of ANSI Z358.1.
- B. Install associated mixing valves directly above (in unfinished spaces), in ceiling void above (in finished spaces, or in millwork below fixture (for eyewash) as close as possible. Preset discharge water temperature to 85 degree F. Coordinate desired discharge temperature with Owner and adjust as required.

- C. Required universal safety signage and inspection tag installation shall be coordinated with the Architect.
- D. Include a copy of ANSI Z358.1 in the Operation and Maintenance Manual.

3.07 INTERFACE WITH WORK OF OTHER SECTIONS

- A. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation, especially with regard to ADA/ABA clearances.
- B. Coordinate the electrical connection of all plumbing components requiring power.

3.08 FIELD QUALITY CONTROL

- A. Verify that all plumbing fixtures are of the correct type and are located as indicated in the Plumbing Documents.
- B. Check to insure that the plumbing fixtures are installed complete with all trim, faucets, fittings, and other components as required by the Plumbing Documents.
- C. Inspect installed plumbing fixtures for damage.
- D. Test all installed fixtures for proper operation after the supply water systems are pressurized. Replace malfunctioning fixtures and components and then retest. Repeat procedure as required until fixture operates properly.
- E. Observe that all fixtures drain properly without leakage. Clean as required and replace defective components.
- F. Repair or replace damaged products before Date of Substantial Completion.
- G. After completing installation and cleaning of all exposed fixture components, inspect exposed finishes and repair damage in a manner acceptable to the Architect. Replace if finish cannot be properly repaired.

3.09 ADJUSTING

- A. Operate and adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.
- B. Operate and adjust all faucets and other flow control devices. Replace damaged or malfunctioning components.
- C. Replace washers, seals, cartridges, or other devices of leaking and dripping faucets and stops.
- D. Install fresh batteries in senso-operated mechanisms.

3.10 CLEANING

- A. Clean plumbing fixtures' components with manufacturer's recommended cleaning method and materials. Include the following:
 - 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall components.
 - 2. Remove sediment and debris from drains.

3.11 PROTECTION

- A. Protect installed products from damage due to subsequent construction operations.
- B. Do not permit use of fixtures by construction personnel.

END OF SECTION

**SECTION 22 43 00
HEALTHCARE PLUMBING FIXTURES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Work includes providing new hospital plumbing fixtures and related work.
- B. Fixtures include:
 - 1. Automatic surgical scrub stations.
- C. Providing rough-in and making final plumbing connections to equipment furnished under other specification sections.

1.02 REFERENCE STANDARDS

- A. ASME A112.6.1M - Floor-Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use 1997 (Reaffirmed 2017).
- B. ICC (IPC) - International Plumbing Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. NSF 61 - Drinking Water System Components - Health Effects 2022, with Errata.
- D. NSF 372 - Drinking Water System Components - Lead Content 2022.

PART 2 PRODUCTS

2.01 GENERAL

- 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.

2.02 ELECTRICAL MOTORS, CONTROLLERS, CONTACTORS, AND DISCONNECTS

- A. Furnish motors, controllers, contactors, and disconnects with their respective pieces of equipment.
- B. Controllers and contractors shall have a maximum of 120-volt control circuits, and auxiliary contacts for use with the controls furnished.

2.03 PLUMBING FIXTURES, FITTINGS, ACCESSORIES, AND SUPPLIES

- A. General Requirements:
 - 1. Provide control stop valves on each supply to each fixture.
 - 2. Provide chromium-plated finish on fittings and accessories exposed to view.
 - 3. Fixture dimensions specified are nominal.
- B. Scrub Station, Surgical, Automatic:
 - 1. Wall mounted, 14 gauge, 0.0781 inch, Type 304, welded stainless steel scrub sink with 1 or 2 automatic scrub stations.
 - 2. Provide each station with volume regulator, thermostat controlled water temperature selector, solid state electronic timer with automatically timed scrub period, gooseneck spout with full arm wash/rinse spray, automatic water shut-off, built-in detergent dispenser, foot controls, perforated strainer, 1-1/2 inch tailpieces, and 1-1/2 inch cast brass P-trap.
 - 3. Provide plastic splash shields between scrub stations.
 - 4. Temperature controls and timing devices: Watertight and enclosed to prevent tampering.
 - 5. Provide 1/2 inch lines with hot and cold water at a pressure between 20 psi and 50 psi and 120 volt, 60 hertz, single phase power to an internal junction box.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install each fixture with trap, easily removable for servicing and cleaning.
- B. Install fixtures and fittings in accordance with the manufacturer's instructions and in accordance with the applicable codes.

- C. When fixtures require both hot water and cold water supplies, provide the hot water supply to the left of the cold water supply.
- D. Install off-the-floor supports to comply with ASME A112.6.1M.
- E. Adjust water flow rates to comply with manufacturer's rating of the fixture.

3.02 CLEANING

- A. Thoroughly clean plumbing fixtures and equipment.

3.03 PROTECTION

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

END OF SECTION

SECTION 22 60 05
MEDICAL AIR, GAS, AND VACUUM SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Medical compressed air systems.
 - 1. Medical air.
- B. Medical gas systems.
 - 1. Medical oxygen.
 - 2. Medical nitous oxide.
 - 3. Medical carbon dioxide.
- C. Medical vacuum system.
 - 1. Medical vacuum - Surgical vacuum at 15 inches mercury
 - 2. Waste anesthetic gas disposal (WAGD) vacuum - 14 inches mercury.
- D. Non-medical systems.
 - 1. Instrument air.
 - 2. Specialty gases.

1.02 REFERENCE STANDARDS

- A. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2021.
- B. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2021.
- C. ASME B40.100 - Pressure Gauges and Gauge Attachments 2022.
- D. ASTM B32 - Standard Specification for Solder Metal 2020.
- E. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- F. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- G. ASTM B819 - Standard Specification for Seamless Copper Tube for Medical Gas Systems 2019.
- H. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120 2021a.
- I. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40 2021.
- J. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems 2020.
- K. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2019.
- L. CGA G-7 - Standard for Compressed Air for Human Respiration 2019.
- M. CGA V-5 - Standard for Diameter Index Safety System (Noninterchangeable Low Pressure Connections for Medical Gas Applications) 2019.
- N. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).
- O. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves 2019.
- P. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends 2010, with Errata .
- Q. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- R. NFPA 99 - Health Care Facilities Code 2021, with Amendment.

1.03 ABBREVIATIONS AND DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. D.I.S.S.: Diameter-index safety system.

- C. Low voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 volts for remote-control, signaling power-limited circuits.
- D. WAGD: Waste anesthetic gas disposal.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturers literature and illustrations for all components indicating size, dimensions and configuration.
- B. Shop Drawings: Indicate general assembly of components, mounting and installation details, and general layout of control and alarm panels. Submit detailed medical wall assembly drawings. Diagrams for power, signal, and control wiring.
- C. Certificates: Certify that products meet or exceed specified requirements.
- D. Independent Testing Agency Reports: Indicate systems are complete, zone valves installed, alarm systems functional, and pressure and cross connections tests performed. Document tests.
- E. Manufacturer's Instructions: Indicate installation requirements for equipment and systems.
- F. Manufacturer's Field Reports: Indicate systems are complete, zone valves installed, and alarm systems functional.
- G. Operation Data: Include installation instructions, assembly views, lubrication instructions, and assembly views.
- H. Maintenance Data: Include maintenance and inspection data, replacement part numbers and availability, and service depot location and telephone.
- I. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- J. Project Record Documents: Record actual locations of piping, valving, and outlets.

1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with NFPA 99.
- 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 three years of documented experience.
- D. Brazing Qualifications: Employ only qualified journeymen. Provide brazers performance qualification test records for each brazer used on installation. All brazers shall be qualified per NITC/ASSE 6000 series certification, 37 minimum hours training course and possess a valid certification card at all times while brazing a medical gas system.
- E. Certifier Qualifications: The certifier shall be licensed to ASSE 6000 series, and P.I.P.E. 6030, Level M4 or equivalent. Certifier to be member of M.G.P.H.O. organization of medical gas verifiers.
- F. Comply with applicable codes for medical gas systems.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept material on site in factory containers and packing. Inspect for damage.
- B. Protect from damage and contamination by maintaining factory packaging and caps in place until installation.

1.07 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for medical source equipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Allied Healthcare Products, Inc
- B. Amico Corporation
- C. BeaconMedaes

2.02 PIPE AND FITTINGS

- A. Copper medical gas pipe, above grade/slab.
 - 1. Manufacturer cleaned, purged, and sealed pipe and fittings for medical gas service as required for oxygen service according to CGA G-4.1 "Cleaning Equipment for Oxygen Service".
 - 2. Pipe: ASTM B819, Type K or L (as scheduled for service), seamless drawn temper with standard marking "OXY", "MED", "OXY/MED", "OXY/ACR", or "ACR/MED" in green for Type K or blue for Type L.
 - 3. Fitting: ASME B16.22, wrought copper.
 - 4. Joints: AWS A5.8M/A5.8 Classification BCuP-3 or BCuP-4 silver braze.

2.03 VALVES

- A. Factory Preparation for Oxygen Service: Disassemble, clean, degrease, seal, and pack for shipping.
- B. Ball Valves:
 - 1. Requirements: Comply with MSS SP-110; bronze body, three piece, double-seal ball valves with replaceable neoprene or teflon seat and stem seals, for minimum 600 psi cold working pressure, flange or union mounting, labeled for intended service.
- C. Pressure Regulation Valves (Medical Air):
- D. Gate Valves (Vacuum, Medical Air, and Anesthesia Gas Evacuation System):
 - 1. MSS SP-80; Class 150 bronze body, bronze trim, rising stem, handwheel, inside screw, solid wedge disc, solder ends.

2.04 PIPING ACCESSORIES

- A. Hangers and Supports: MSS SP-58 with types as required.
- B. Pressure Gauges:
 - 1. ASME B40.100, white dials and black lettering with restrictor.
 - 2. Oxygen and nitrous oxide systems: Manufactured and labeled expressly for intended service; UL labeled.
- C. Vacuum Bottle Brackets: Stainless steel, chrome-plated metal, or aluminum with finish matching adjacent outlet.
- D. Flexible Connectors: Corrugated flexible, single ply, seamless or seam-welded tubing of stainless steel or bronze or reinforced teflon bellows or hose.
- E. Valve Cabinets:
 - 1. Extruded aluminum, flush-mounted and rigidly assembled to accommodate valves and fittings, punched or drilled sides to receive tubing, anchors to secure to wall construction.
 - 2. Cover Plates: Extruded aluminum, with replaceable plastic windows with pull ring to remove window.
 - 3. Cabinet Labels: labeled and color coded for intended service and area served.
 - 4. Valves: Pre-assemble and mount chrome plated valves and tubing extensions.
 - 5. Gauges: Provide where indicated and in operating rooms areas downstream of isolating valves.
- F. Piping Identification: Pressure sensitive adhesive tape and decals, color and labeling.

2.05 OUTLETS

- A. Outlet Units:
 - 1. Manufacturers:
 - a. Allied Healthcare Products, Inc
 - b. Amico Corporation

- c. BeaconMedaes
 - d. Powerex.
 - 2. NFPA 99 non-interchangeable connectors, automatic valves, secondary check valves (except vacuum and evacuation outlets), and capped 3/8 inch tubing stubs for supply connections, color coded and labeled for intended service.
 - 3. Recessed wall outlets shall be quick connect type. Contractor shall verify connection type with Owner prior to procurement.
 - 4. Ceiling outlets shall be D.I.S.S. type and provided with hoses and hose retractors.
- B. Faceplates:
- 1. Flush Outlets: Mount in galvanized steel boxes with stainless steel faceplate with Lexan cover, color coded with embossed labeling.
 - 2. Surface Outlets: Surface mount with color coded plastic cover and stainless steel faceplate with Lexan cover, color coded with embossed labeling.

2.06 NITROUS OXIDE MANIFOLD

- A. Manufacturers:
- 1. Allied Healthcare Products, Inc
 - 2. Amico Corporation
 - 3. BeaconMedaes
 - 4. Powerex.
- B. Central Supply of Nitrous Oxide: Duplex automatic manifold consisting of wall mounted control cabinet and necessary header connections and pigtails for 8 cylinders, arranged for 4 cylinders in service and 4 cylinders in reserve.
- C. Manifold Delivery: Maximum 220 cfh nitrous oxide continuously at 50 psi. Provide automatic changeover from primary to secondary bank and allow replacing depleted cylinders with no change in line pressure.
- D. By-Pass System: Between regulators to service regulator or switch over system without interrupting supply of gas. Bleed valves piped to vent connector within cabinet shall allow adjustment of pressure reducing regulators.
- E. Cabinet: House components in lockable cabinet with baked enamel finish.
- 1. Three front mounted gauges indicate bank and hospital line pressures.
 - 2. Green indicator light indicates service bank in use.
 - 3. Red indicator light indicates reserve bank in use.
 - 4. Provide terminal block connections for remote alarms.

2.07 NITROGEN MANIFOLD

- A. Manufacturers:
- 1. Allied Healthcare Products, Inc
 - 2. Amico Corporation
 - 3. BeaconMedaes
 - 4. Powerex.
- B. Duplex Nitrogen Manifold: Consist of wall mounted control cabinet and necessary header connection and pigtails for 8 cylinders. Arrange controls to have half of cylinders in service and half in reserve.
- C. Manifold Delivery: Maximum 220 cfh nitrogen continuously at 180 psi. Provide automatic changeover from primary to secondary bank and allow replacing depleted cylinders with no change in line pressure. Provide bank regulators to reduce cylinder pressure for line regulator set at 160 psi delivery pressure. Provide manifold relief valve set at 240 psi.
- D. By-Pass System: Between regulators to service regulator or switch over system without interrupting supply of gas. Bleed valves allow adjustment of pressure reducing regulators.
- E. Cabinet: House components in lockable cabinet with baked enamel finish.
- 1. Three front mounted gauges indicate bank and hospital line pressures.
 - 2. Green indicator light indicates service bank in use.

3. Red indicator light indicates reserve bank in use.
4. Provide terminal block connections for remote alarm.

2.08 CARBON DIOXIDE MANIFOLD

- A. Manufacturers:
 1. Allied Healthcare Products, Inc
 2. Amico Corporation
 3. BeaconMedaes
 4. Powerex.
 5. Substitutions: See Section 01 60 00 - Product Requirements.
- B. Duplex Carbon Dioxide Manifold: Consist of wall mounted control cabinet and necessary header connection and pigtails for 8 cylinders. Arrange controls to have half of cylinders in service and half in reserve.
- C. Manifold Delivery: Maximum 220 cfh nitrogen continuously at 180 psi. Provide automatic changeover from primary to secondary bank and allow replacing depleted cylinders with no change in line pressure. Provide bank regulators to reduce cylinder pressure for line regulator set at 160 psi delivery pressure. Provide manifold relief valve set at 240 psi.
- D. By-Pass System: Between regulators to service regulator or switch over system without interrupting supply of gas. Bleed valves allow adjustment of pressure reducing regulators.
- E. Cabinet: House components in lockable cabinet with baked enamel finish.
 1. Three front mounted gauges indicate bank and hospital line pressures.
 2. Green indicator light indicates service bank in use.
 3. Red indicator light indicates reserve bank in use.
 4. Provide terminal block connections for remote alarm.

2.09 MEDICAL COMPRESSED AIR SYSTEM

- A. Manufacturers:
 1. Allied Healthcare Products, Inc
 2. Amico Corporation
 3. BeaconMedaes
 4. Powerex.
- B. Triplex Air Compressor System:
 1. To deliver CGA G-7 compressed air.
 2. Oil Free Scroll Compressors: Equipped with check valve, inlet and outlet flexible connector, isolation valve, safety relief valve, air by-pass solenoid valve, strainer, compound gauge, solenoid valve, inlet mufflers, motor coupling with guard.
- C. Dessicant Air Dryers: Non-cycling hermetic type with automatic drain trap, three valve by-pass system, motor and safety disconnect switch in NEMA 250 Type 1 general purpose enclosure, wired from compressor controller.
- D. Triplex Controller: Pre-wired in NEMA 250 Type 12 enclosure with fusible disconnects, magnetic motor starters with overload protection, control circuit transformers, clock timer, pressure switches, hand-off automatic selector switches mounted in cabinet cover, and safety disconnect door.
- E. Receiver: Welded steel ASME receiver, prime coated with vinyl lining, with gauge, safety relief valve, and automatic tank drain.
- F. Air Line Filter Regulator: Regulating assembly with line pressure adjusting knob, 2 inch diameter line pressure gauge, 1-1/4 inch pipe size connections, clear polycarbonate collection bowl with 5 micron filter unit and automatic drain.

2.10 MEDICAL VACUUM AND WAGD SYSTEM

- A. Manufacturers:
 1. Allied Healthcare Products, Inc
 2. Amico Corporation

3. BeaconMedaes
4. Powerex.
- B. Duplex Vacuum Pump:
 1. Claw Pumps: Tank mounted, each equipped with check valve, inlet flexible connector, water separator, strainer, compound gauge, solenoid valve and metering valve for service liquid, exhaust muffler, motor coupling with guard, and suitable for handling flammable gases. Oxygen safe for WAGD use.
- C. Electrical Controls: Pre-wired in NEMA 250 Type 12 enclosure, with fusible disconnects, magnetic motor starters, overload protection with manual reset, control circuit transformers, automatic alternators, vacuum control switches, hand-off automatic switches in cabinet cover, and safety disconnect door.
- D. Receiver: Welded steel ASME receiver, prime coated with vinyl lining, with gauge, safety relief valve, and automatic tank drain.

2.11 OXYGEN MANIFOLD

- A. Manufacturers:
 1. Allied Healthcare Products, Inc
 2. Amico Corporation
 3. BeaconMedaes
- B. Automatic Manifold: Consisting of wall mounted control cabinet and necessary header connections and pigtails for 2 microbulk oxygen containers, arranged for 1 cylinders in service and 1 cylinders in reserve. Provide necessary header connections and pigtails for 4 in building emergency reserve cylinders.
- C. Delivery: Maximum 220 cfm oxygen continuously at 50 psi. Provide automatic changeover from primary to secondary bank and allow replacing depleted cylinders with no change in line pressure.
- D. By-Pass System: Locate between regulators to service regulator or switch over system without interrupting supply of gas. Pipe bleed valves to vent connector within cabinet to allow adjustment of pressure reducing regulators.
- E. Cabinet: House components in lockable cabinet with baked enamel finish.
 1. Three front mounted gauges: Indicate bank and hospital line pressures.
 2. Green indicator light: Indicate service bank in use.
 3. Red indicator light: Indicate reserve bank in use.
 4. Terminal block: Connections for remote alarms.

2.12 ALARM SYSTEM

- A. Manufacturers:
 1. Allied Healthcare Products, Inc
 2. Amico Corporation
 3. BeaconMedaes
 4. Powerex.
- B. Multi-Signal Alarm Panel:
 1. Closed circuit, self-monitoring type, to monitor oxygen, vacuum, compressed air, nitrous oxide, and nitrogen piping systems pressure or liquid level. Provide with communications card or gateway for integration into Building Automation System.
 2. Green light for systems normal.
 3. For abnormal condition:
 - a. Green light extinguishes.
 - b. Audible warning device sounds.
 - c. Red light energizes.
 4. Switch silences warning device.
 5. Test switch to test light bulbs and audible warning device.

6. Design system such that one, two or more monitors may be connected to a single pressure switch.
7. Monitor following abnormal conditions:
 - a. Oxygen reserve supply in use.
 - b. Oxygen line pressure high.
 - c. Oxygen line pressure low.
 - d. Air line pressure high.
 - e. Air line pressure low.
 - f. Air lag pump on.
 - g. Vacuum line pressure above normal.
 - h. Vacuum line pressure below normal.
 - i. Nitrous oxide reserve supply in use.
 - j. Nitrous line pressure high.
 - k. Nitrous line pressure low.
 - l. Nitrogen reserve supply in use.
 - m. Nitrogen line pressure high.
 - n. Nitrogen line pressure low.
8. High-Low Pressure Switch: Dual circuit with two single pole, double throw, snap action switches, tested at 180 psi with adjustable range of 4 psi, preset at 40 psi and 60 psi.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with NFPA 99.
- B. Braze joints in pipe and tubing. Avoid leaving excess flux inside of pipe and fittings. During brazing of pipe connections, purge interior of pipe continuously with nitrogen.
- C. Effect changes in size with reducing fittings. Make changes in direction of required turns or offsets with fittings or tubing shaped by bending tools. Make bends free of flattening, buckling or thinning of tube wall.
- D. Cut pipe and tubing accurately and install without springing or forcing.
- E. Install exposed oxygen piping in wall-mounted sheet steel raceways and junction boxes.
- F. Grade piping down in direction of flow.
- G. Provide pipe sleeves where pipes and tubing pass through walls, floors, roofs, and partitions.
- H. Identify piping with tape and decals.
- I. Support gas piping with hangers suitable for size of pipe, spaced:
 1. 1/2 inch pipe or tubing: 72 inches.
 2. 3/4 inch or one inch pipe or tubing: 96 inches.
 3. 1-1/4 inches or larger (horizontal): 120 inches.
 4. 1-1/4 inches or larger (vertical): Every floor level.
- J. Except where indicated or in flush wall mounted cabinets, install manual shut off valves with stem vertical and accessible for operation and maintenance.
- K. Install strainers on inlet side of pressure reducing valves. Provide main gas valves (pressure reducing or flow control) with by-passes and isolation valves to permit maintenance without interruption of gas.
- L. Provide a valved by-pass around receivers.
- M. Medical Air Compressor Systems: 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.

3.02 PIPING SYSTEMS CLEANING AND PRESSURE TESTING

- A. After erection of pipe and tubing but prior to installation of service outlet valves, blow systems clear of free moisture and foreign matter with nitrogen gas.

- B. Install service outlet valves, subject system to test pressure of 150 psi with nitrogen or dry compressed air. Check with soapy water. Provide 24-hour standing pressure test.

3.03 SYSTEMS TESTING

- A. Perform the following tests and submit all findings to HCA ASD Engineering Director and Engineer.
 - 1. Purity test.
 - 2. Cross connection.
 - 3. Operating pressures.
 - 4. Alarm monitoring.
 - 5. Labeling of system components.
 - 6. Equipment function and operation.

3.04 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Startup to be performed by a manufacturer's representative and shall be coordinated with the medical gas/vacuum system certifier.
- C. Independent testing agency to certify system is complete, zone valves installed, alarm systems functional, and tests performed. Document tests and submit.
- D. Reduce pressure in piping systems other than system under investigation to atmospheric.
- E. Test system with dry compressed air or dry nitrogen with test pressure in piping system at 50 psi.
- F. Check each station outlet of every piping system to determine test gas is dispensed only from outlet of system under investigation. Measure pressure with gauge attached to specific adaptor. Do not use universal adaptors.
- G. Disconnect test gas and connect proper gas to each system. Purge entire system to remove test gas. Purge gas to be medical grade nitrogen (NF) only. Check with analyzer suitable for gas installed.

END OF SECTION

SECTION 23 01 30.51
HVAC AIR-DISTRIBUTION SYSTEM CLEANING

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 DEFINITIONS

- A. HVAC System: For purposes of this section, the surfaces to be cleaned include all interior surfaces of the heating, air-conditioning and ventilation system from the points where the air enters the system to the points where the air is discharged from the system, including the inside of air distribution equipment, coils, and condensate drain pans; see NADCA ACR for more details.

1.03 REFERENCE STANDARDS

- A. NADCA ACR - The NADCA Standard for Assessment, Cleaning, and Restoration of HVAC System 2021.
- B. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors current edition, including all revisions.
- C. UL 181A - Closure Systems for Use with Rigid Air Ducts Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. Qualifications Statement: Submit qualifications of proposed cleaning contractor for approval.
- B. Project Cleanliness Evaluation and Cleaning Plan, as specified.
- C. Material Safety Data Sheets (MSDS): For all chemical products proposed to be used in the cleaning process; submit directly to Owner.
- D. Project Closeout Report: Include field quality control reports, evidence of satisfactory cleaning, and documentation of items needing further repair.

1.05 QUALITY ASSURANCE

- A. Information Available to Contractor: Upon request, Owner will provide the following:
 - 1. One copy of original construction drawings of HVAC system.
 - 2. One copy of original construction specifications of HVAC system.
- B. Cleaning Contractor Qualifications: Company specializing in the cleaning and restoration of HVAC systems as specified in this section.
 - 1. Certified by one of the following:
 - a. NADCA, National Air Duct Cleaners Association: www.nadca.com
 - 2. Having minimum of three years documented experience.
 - 3. Employing for this project a supervisor certified as an Air Systems Cleaning Specialist by NADCA.

PART 2 PRODUCTS

2.01 TOOLS AND EQUIPMENT

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

PART 3 EXECUTION

3.01 PROJECT CONDITIONS

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

3.02 PREPARATION

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

3.03 CLEANING

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

- H. Store contaminated tools and equipment in polyethylene bags until cleaned in the designated decontamination area.

3.04 REPAIR

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

3.05 FIELD QUALITY CONTROL

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

3.06 ADJUSTING

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

3.07 WASTE MANAGEMENT

- A. Double-bag waste and debris in 6 mil, 0.006 inch thick polyethylene plastic bags.
- B. Dispose of debris off-site in accordance with applicable federal, state and local requirements.

END OF SECTION

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**SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC**

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish all material, equipment, tools, labor, and services as necessary & required to construct the fully coordinated, complete, and properly functioning HVAC Systems as outlined in the Contract Documents.
- B. Section includes:
 - 1. General Requirements for Bidding and the Construction of the HVAC Systems.
 - 2. General Requirements for Material and Equipment
 - 3. Sustainability Requirements.
 - 4. Dielectric Fittings.
 - 5. Pipe Escutcheons.
 - 6. Pipe Penetration Roof Curb.
 - 7. Wood Stud Guards, Shields, and Stud Shoes.
 - 8. Delivery, Storage, and Handling.
 - 9. Earthwork.
 - 10. General Installation Requirements.
 - 11. Sustainability Requirements.
 - 12. Miscellaneous Construction Coordination.
 - 13. Dielectric Fitting Installation.
 - 14. Pie Escutcheon Installation.
 - 15. Pipe Roof Penetration Installation
 - 16. Erection of Metal Supports and Anchorage.
 - 17. Erection of Wood Supports and Anchorage.
 - 18. Damage and Touch-up Painting.
 - 19. Protection and Cleaning
- C. Obtain and pay for all permits, fees and licenses required for the construction and acceptance of the HVAC Systems by all Authorities-having-Jurisdictions (AHJs).
- D. Be responsible for all aspects of the HVAC systems' material condition, installation, operation, and maintenance until accepted by the Owner.
- E. The Engineer's definition for the HVAC portion of the Contract Documents (hereinafter referred to as the HVAC Documents) consist of:
 - 1. All Specification Division 23 Sections.
 - 2. All Mechanical (M) Drawings.
 - 3. HVAC portions of work shown on Mechanical/Plumbing (MP) or Mechanical/Electrical/Plumbing (MEP) Drawings.
 - 4. Other portions of the Contract Documents referenced in the Division 23 Specifications and the Mechanical Drawings.
 - 5. All HVAC/Mechanical-related Addendum items.

1.02 RELATED DOCUMENTS

- A. This section, General HVAC Requirements, is specifically applicable to all Division 23 Specification Sections.
- B. If procedures, directions, or requirements are mentioned in other portions of the Contract Documents that pertain to or interact with work shown in the HVAC Documents, the most stringent requirement will be utilized unless directed otherwise by the Architect as specified in Division 1.
- C. Be thoroughly familiar with all portions of the Contract Documents to ensure that all HVAC equipment, material, and work are fully coordinated with all other aspects of this Project.
- D. Listing of Specification Sections and Drawings below is intended to highlight other relevant portions of the Contract Documents that apply to the HVAC Documents, should be considered

a courtesy, and does not relieve the Contractor from coordinating the HVAC Work with all other parts of the Contract Documents.

1. Division 0 "Procurement and Contracting Requirements" - General and Supplemental or Special Conditions of the Contract.
 2. Division 1 "General Requirements" - All sections.
 3. Division 3 "Concrete" - Housekeeping pads and equipment supports.
 4. Division 5 "Metals" - Miscellaneous metal supports not specified hereinafter in Division 23.
 5. Division 6 "Woods, Plastics, and Composites – Fire-retardant-treated-wood blocking.
 6. Division 7 "Thermal and Moisture Protection":
 - a. Sealing of pipe sleeves.
 - b. Flashing and sealing of roof penetrations.
 - c. Sealing of wall penetrations.
 - d. Through and membrane penetration's firestopping for fire and smoke rated assemblages.
 7. Division 8 "Openings" – Architectural access door coordination and louver requirements.
 8. Division 9 "Finishes" - Painting of HVAC systems for aesthetic or identification purposes.
 9. Division 11 "Equipment" - Food service, laboratory, or other equipment with HVAC connection requirements.
 10. Division 12 "Furnishings" - Casework and wall-mounted items.
 11. Division 26 "Electrical" – Control-voltage electrical cables.
 12. Division 28 "Electronic Safety and Security" – Interconnection with other electronic systems.
 13. Division 31 "Earth Moving" - Excavating, trenching and backfilling.
 14. Division 33 "Utilities" – Site utilities.
 15. Architectural Drawings:
 - a. Applicable Codes and Standards.
 - b. Reflected ceiling plans for elevations and types of ceilings
 - c. Interior elevations for coordination with casework and wall-mounted HVAC component locations.
 - d. Location of fire/smoke rated construction and egress paths.
 16. Electrical Drawings:
 - a. Location of power connections for Building Management System's low-voltage transformers.
 - b. Power connection and requirements for HVAC equipment.
 17. Plumbing Drawings:
 - a. Flue and combustion air duct requirements for water heaters.
 - b. Additional information required for the connection of equipment to the HVAC systems.
 18. Kitchen Equipment Documents – Additional information required for the connection of equipment to the HVAC systems.
 19. Lab Equipment Documents - Additional information required for the connection of equipment to the HVAC systems.
 20. Medical Equipment Documents – Additional information required for the connection of equipment to the HVAC systems.
- E. If the above referenced related documents are not part of the Contract Documents, request a project specific copy from the Architect as specified in Division 1.

1.03 ABBREVIATIONS & DEFINITIONS

- A. AFF: Above the finished floor.
- B. AHJ: Authority having Jurisdiction.
- C. ANSI: American National Standards Institute.
- D. ASTM: ASTM International, formally known as American Society of Testing and Material.
- E. ASHRAE: American Society of Heating, Refrigeration, and Air-Conditioning Engineers.

- F. AWS: American Welding Society.
- G. Commodity items: Those HVAC components that comply with a specific standard and are identical in construction/manufacturing from one supplier to another, such as copper pipe and fittings.
- H. Component: Any pipe, fitting, valve, specialty, duct, diffuser/register/grille, specialty, piece of equipment or other item required for the complete and fully functioning HVAC system.
- I. Concealed: Items which are completely hidden from view by building elements (walls, ceilings, floors, etc.) under normal conditions from any angle or point-of-view to building occupants or people outside the building.
- J. Conditioned: Interior spaces that are heated and cooled providing some level of humidity control.
- K. CPS: Copper pipe size.
- L. CWP: Cold working pressure.
- M. Exposed: Items which are visible under normal conditions from any angle or point-of-view to building occupants or people outside the building.
- N. Exterior: Area or items located outside, subject to any portion of the ambient weather conditions, and unprotected by the building's complete thermal and moisture barriers.
- O. Finished Spaces: Spaces that are accessible to building occupants at some time except those spaces such as mechanical/electrical/elevator equipment rooms, janitor closets, furred spaces, pipe and duct shafts, unconditioned spaces immediately below the roof, void spaces above ceilings, crawlspaces, and tunnels.
- P. g/l: Grams per liter.
- Q. Inches wg: inches water gage pressure.
- R. Interior: Area or items located inside and completely protected by the building's thermal and moisture barriers.
- S. IPS: Iron pipe size.
- T. Max: Maximum.
- U. Means of Mechanical Disconnection: Providing a way of disconnection that can be reconnected utilizing only the original parts and does not require the destruction of any part of the original connection. Unions, screw fittings, and flanges for piping and slip or screwed connections for ducts are means of mechanical disconnection. Soldering, welding, gluing, or riveting are not considered types of mechanical disconnection.
- V. Min: Minimum.
- W. MPT: Male pipe thread.
- X. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.
- Y. NFPA: National Fire Protection Association.
- Z. NPS: Nominal pipe size.
- AA. NPT: National Pipe Thread Taper.
- BB. NRTL: Nationally Recognized Testing Laboratory as designated by OSHA.
- CC. Pipe: A rigid conduit used to convey fluid or gas.
- DD. Piping: Refers to both pipe and tubing.
- EE. Private Spaces: Those spaces that are not available for all occupants to use.
- FF. psig: pounds per square inch, gage pressure.
- GG. Public Spaces: Those spaces that are available for all or most occupants to use.
- HH. Tempered: Interior spaces that are heated only with no level of humidity control.
- II. Tubing: A flexible conduit used to convey fluid or gas.

JJ. VOC: Volatile organic compounds.

KK. WOG: Water, Oil, Gas.

1.04 CODES, ORDINANCES, AND STANDARDS

- A. Refer to the Architectural Code Review portion of the Contract Documents for the specific Code(s) under which the Project was designed.
- B. All aspects of the applicable Code(s) are not specifically stated in the HVAC Documents but are required for final installation.
- C. All references to industry standards (Example: ASTM, MSS, SMACNA) in these Specifications refer to the most current edition of that standard unless the Mechanical Code in force references or the AHJ publically requires a specific edition.

1.05 INTENT OF HVAC DOCUMENTS

- A. Manufacturer and model numbers are given as a basis of design. Stated basic model numbers may not utilize all the manufacturer's extended model number that outlines all options required.
- B. The HVAC Documents are not complete construction documents and are not intended for final system installation.
 - 1. Because of their small scale and variations of different manufacturers' equipment; the HVAC drawings are diagrammatic, cannot be rigid in specific details for the final installation of the systems, and should not be scaled.
 - 2. Routing of piping and ducts on the floor plans is for the clarity of the drawings, may not show exact location, may not show all required offsets/transitions/spacing, and shall be field coordinated.
 - 3. General location of equipment and specialties are indicated but may not show all details required for the final installation.
 - 4. Details and diagrams are provided to indicate minimum installation requirements and may require some modification to accommodate individual pieces of equipment or systems.
- C. When the HVAC Documents conflict with the manufacturer's recommendations for the installed/connected equipment that would adversely affect its operation or useful life, make such adjustments that are required to ensure that all equipment is installed/connected for the safe and proper operation of the equipment and systems served.

1.06 REVIEW, INTERPRETATION, & CORRECTION OF HVAC DOCUMENTS

- A. Thoroughly review all portions of the Contract Documents to fully coordinate all HVAC items which will be utilized on this Project, including their proper installation.
- B. No one portion of the Contract Documents takes precedent over another portion.
- C. Notify the Architect, as specified in Division 1, in writing prior to Bid Submittal for clarification in a timely manner hereinbefore specified in Division 1 if:
 - 1. The Contractor does not clearly understand or is not completely sure of the meaning of any portion of the HVAC Documents.
 - 2. Any ambiguity, discrepancy, inconsistency or omission in or between the Contract Documents exists or appears to exist regarding the HVAC systems.
- D. If a clarification request is not submitted or should a clarification, decision, or interpretation not be rendered by the Architect as specified in Division 1, it is understood by all Parties that the Contractor will be rigidly held to the interpretation of the Architect with no additional monetary/time changes to the Contractor's original Bid.

1.07 ACCEPTABLE MANUFACTURERS

- A. Acceptable manufacturers stated in other parts of the HVAC Documents are ones that the Engineer considers to be "quality" companies making the same type of equipment as the stated basis of design manufacturer and are provided as a convenience only. Due to the everchanging nature of the manufacturing field, a stated approved manufacturer may not be producing a true equivalent product at the time of the Bid Submittal. The Engineer is the final arbiter of the acceptability of a manufacturer.

- B. Equipment manufacturers other than those listed shall obtain authorization in accordance with the requirements of Division 1. When a manufacturer not listed is acceptable to the Engineer, it means that the manufacturer has been reviewed and judged as a maker of equipment which could possess the similar performance qualities/characteristics and can fulfill the utilitarian functions without any apparent decrease in quality, durability, or efficiency.
- C. The granting of acceptable manufacturer to a company does not constitute acceptance of specific equipment. The Engineer does not pre-review any specific equipment prior to the Submittal/Shop Drawing Review process after the Bid.

1.08 ALTERNATE CONSTRUCTION

- A. Refer to Architect's portion of the Contract Documents for Alternate Construction Work to determine the increase or decrease in the contract price to the Base Proposal for each alternate requested.
- B. Coordinate and modify associated surrounding work as required to accommodate the alternate construction.

1.09 VALUE ENGINEERING (VE)

- A. All proposed VE items shall be fully coordinated with all other affected building systems. Proposed items shall include:
 - 1. Specification (section and paragraph) and drawing (sheet/note, detail, and/or schedule) references related to the VE item.
 - 2. Full and complete information on the proposed VE material/equipment as required to allow the Engineer and Owner to make an informed decision.
 - 3. Denote variations from the originally specified material/equipment and any associated benefit/detriments to the Owner.
 - 4. Denote other building service(s) that will be affected.
 - 5. Estimated changes in the system's useful life.
 - 6. Changes to operational energy efficiency including part-load capabilities and standby losses.
 - 7. Estimated changes to the Project's utility (water, fuel, electrical) usage.
 - 8. Changes required for flues, gas piping, combustion air, electrical service, domestic water service, or other sub-systems needed for the proposed equipment's proper installation and operation.
 - 9. Changes to space requirements for installation and maintenance.
 - 10. Total Project Cost Savings including all savings/ increases for all affected building systems.
- B. Contractor is completely responsible to provide the burden of proof regarding the appropriateness for the intended use of a product. The Engineer is not responsible for performing any additional research to determine the appropriateness of the submitted item.

1.10 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.

1.11 SUBMITTALS/SHOP DRAWINGS

- A. In addition to the requirements of Division 1; provide submittal drawings, catalog data, installation instructions and descriptive literature (as applicable) for all items specified in Part 2 – Products of all Division 23 Sections or for equipment noted/scheduled on the drawings in accordance with the Contract Documents and as hereinafter specified in any Division 23 section.

- B. Coordinate timing of submittals in accordance with Division 1 requirements to provide adequate time for design professionals' review.
- C. Do not provide submittals/shop drawings for equipment that may be affected by the coordination process until after the resolution of the coordination process.
- D. Action Submittals: As a minimum, submittals/shop drawings shall conform to the following requirements.
 - 1. Submittal sheets/product data/shop drawings shall be grouped to include complete submittals of related systems, products, and accessories in a single submittal.
 - 2. Reference shall be made to the specific item's designation, specification section & paragraph, drawing number, & schedule/note/detail/diagram if applicable.
 - 3. Provide values or information for all items listed in the specification, schedules, or as noted elsewhere in the HVAC Documents. Values shall be in units to match those designated in the HVAC Documents.
 - 4. If standard manufacturer's data or submittal sheets are utilized, they shall be marked definitively and legibly to indicate specifically which size(s) or option(s) are being provided.
 - 5. Include mounting requirements with anchorage locations.
 - 6. Include wiring diagrams for power and control/signal wiring.
 - 7. Include pump or fan curves.
 - 8. Include a Statement of Compliance, on the manufacturer's letterhead, for the specified referenced standards if not included on their standard product data/submittal sheet.
 - 9. Manufacturer's standard color charts for selection of color by the Architect.
 - 10. If submitted equipment has not been available in the United States of America (USA) for a minimum of three (3) full years, submittal shall include a list of installations in the USA and the year installed.
- E. Informational Submittals:
 - 1. Welding Certificates
 - 2. Field quality-control reports
 - 3. A copy of the installation manual, if one is published by the manufacturer, shall be included. They will not be reviewed by the Engineer but need to be kept on the job site during construction.
 - 4. A copy of the manufacturer's warranty.
- F. Submit a specification compliance review where indicated in individual sections.
 - 1. At each paragraph of the specification indicate in the left hand margin if the paragraph "NA" not applicable, "C" complies or "E" exception. Explain fully any exceptions to the paragraphs. Shop drawings and product data will not be reviewed with out submitting the specification compliance review.
- G. Samples: Not required for Division 23 items unless noted hereinafter in other Division 23 sections.
- H. Sustainability Submittals: Comply with the requirements specified in Division 01 - Sustainable Design Requirements section(s) and as hereinafter specified. If not part of the Contract Documents, request a copy of the sustainability checklist to determine which HVAC system related sustainability requirements are being pursued.
 - 1. All proposed HVAC system components shall not adversely affect the ability of this Project to achieve the desired sustainability rating.
 - 2. All proposed HVAC system components shall not adversely affect the energy or water usage of the building.
 - 3. Field-applied adhesives and sealants shall comply with the maximum sustainability VOC content limits.
- I. Completely and thoroughly review all submittals/shop drawings for conformance with the Contract Documents prior to forwarding it to the Architect as specified in Division 1.
 - 1. Contractor is completely responsible to provide the burden of proof regarding equivalency of a product. The Engineer will not be responsible for performing any additional research to determine the equivalency of the submitted item.

2. All requirements for the products shown in the HVAC Documents shall be adhered to and provided.
 3. Submit complete information concerning all changes in the project required by the submitted products including detailed dimensional layouts of equipment, details of all required MEP service connections, clearances required for service and maintenance, weight, physical arrangement, engineering calculations, and all data necessary to assure that the equivalent product can be properly installed and operated in accordance with the requirements of the Contract Documents.
 - a. Review installation and maintenance information to determine if any changes or specific installation instructions are required for any associated building system.
 4. Any re-engineering or design changes required for any associated building system to accommodate the proposed product shall be coordinated and provided by the Contractor. Required changes shall be in accordance with the Contract Documents and submitted for review by the Engineer. Examples include, but are not limited to, sizes of electrical wiring/conduits/breakers, gas piping, flues, combustion air ducts, etc.
 5. Attention should be specifically given to the space limitations for the location of the submitted equipment and any manufacturer's recommended operational and maintenance clearances.
- J. Highlight and clearly call to the Engineer's attention:
1. Any portion of the submittal/shop drawing that does not comply or varies from the HVAC Document's requirements.
 2. Changes required for any associated building systems.
- K. Electronic copies of the Engineer's drawings may be obtained to use in preparing shop drawings for this specific project. A waiver provided by the Engineer shall be signed and the required fee paid prior to the issuing of the drawing files by the Engineer.
- L. Drawings obtained electronically from the Engineer or electronic reproductions of the Engineer's drawings are not to be considered of adequate detail to be submitted as a shop drawing. Submitted shop drawings shall reflect the following required for coordination.
1. Proposed equipment in lieu of the designed equipment.
 2. Specified items that are not shown on the Engineer's drawings.
 3. Items shown in details, diagrams, or required by drawing notes or schedules.
 4. Clearances around equipment required for access and maintenance.
 5. Elevations of piping, ducts, and equipment.
- M. Submittal will be reviewed by the Engineer for design conformity and general compliance to the Engineer's documents only. Contractor is completely responsible to confirm and correlate:
1. Dimensions at the job site for tolerances and clearances.
 2. Quantities.
 3. Fabrication processes, techniques, and all other ways & means of construction.
 4. Coordination of the HVAC work with other building systems.
 5. Full compliance with the Contract Documents.
- N. If the Engineer has not noted an error in the Contractor's submittal, it does not relieve the Contractor from providing the correct material or equipment to fully comply with the Engineer's documents.
- O. The following are the responses used by the Engineer, a brief description of their meaning, and the subsequent action required by the Contractor. Submittals that contain multiple items may have multiple responses by the Engineer requiring multiple actions by the Contractor.
1. "Reviewed, No Exception Taken": Item(s) submitted appears to meet the requirements of the HVAC Documents.
 - a. No further submittal required.
 2. "Reviewed, Make Corrections Noted": Item(s) submitted appears to meet the requirements of the HVAC Documents except for a few minor items noted.
 - a. No further submittal required. Coordinate minor changes with the equipment supplier prior to ordering and update submittals for inclusion in the Operation and Maintenance Manuals.

3. "Revise and Resubmit": Manufacturer and general qualities of the item submitted meet the intent of the HVAC Documents, but major portions of the item are not acceptable or are missing from the submittal.
 - a. Revise the submittal to conform to the HVAC Documents and resubmit.
 - 1) Only those items that require re-submittal or requested new information will be reviewed after the initial review by the Engineer. Contractor is completely responsible to ensure that no other changes have been made from the previous submittal.
 4. "Rejected": Manufacturer is not equivalent to the Basis of Design or the model/item submitted is of a lesser quality/grade that does not conform to the HVAC Documents.
 - a. Prepare a new submittal with completely different equipment and resubmit.
 5. "Submit Specified Item": Item noted is left out of a submittal of related products.
 - a. Submit only the specific item(s) noted.
 6. "Not Reviewed":
 - a. Submittal has not been reviewed/stamped by the Contractor or is so bad or illegible that a proper review cannot be performed by the Engineer.
 - 1) Prepare a new submittal and resubmit.
 - b. Submittal is for an item not specified in Division 23 but some portion of the submittal needs to be coordinated for connection to a Division 23 system.
 - 1) No further submittal to the Engineer required. Coordinate minor changes with the equipment supplier prior to ordering.
- P. Obtain a positive review (Reviewed, No Exception Taken or Reviewed, Make Corrections Noted) of the material before delivery to the job site.
- Q. Where a submitted product has received a positive review by the Engineer, it does not relieve the Contractor from the responsibility for making all changes in the work necessary and required for a proper and fully functioning installation of the product.

1.12 PRE-CONSTRUCTION COORDINATION

- A. Coordinate the installation of new work with the utility company's requirements.
- B. Location and routing of the HVAC components shall be coordinated with all other building systems prior to installation. First system installed does not settle coordination issues.
- C. As the result of coordination meeting(s) prior to construction, prepare a 3-D model to resolve conflicts between building systems prior to construction to reduce field coordination during construction.
 1. Contact the Architect to determine the availability and requirements to obtain the electronic building model for the verification of all building elements and their dimensions.
- D. Prepare plans drawn to 1/4" = 1'-0" scale with the following items shown and coordinated with each other. Utilize input from installers of the items involved.
 1. Fabrication, assembly and installation of the HVAC systems including plans, elevations, sections, components, and attachments to other work.
 2. Establish and maintain clearance requirements for the field installation of insulation/jackets/finishes and for space required for maintenance.
 3. Duct layout indicating sizes, configuration, elevation, liner/wrap insulating material, and static-pressure classes.
 4. Location and access/maintenance clearances for duct accessories, including but not limited to dampers/actuators, turning vanes, access doors and panels.
 5. Dimensions of main duct runs from building grid lines.
 6. Pipe layout indicating sizes, configuration, elevation, and slope if required.
 7. Location and access/maintenance clearances for pipe accessories, including but not limited to isolation valves, balancing valves, control valves, access doors and panels.
 8. Dimensions of main pipe runs from building grid lines.
 9. Penetrations through fire-rated and other partition.
 10. Installation of submitted/positively reviewed equipment including maintenance clearances.

11. Location of ceiling components such as light fixtures, air inlets/outlets, sprinkler heads, speakers, fire alarm devices, motion detectors, etc. Allow sufficient space for ceiling panel removal. As a rule of thumb, light fixtures get top priority for location in the ceiling. HVAC diffusers/register/grilles get second priority. Sprinkler heads third priority. Then all other devices. (Note: If number of sprinkler heads can be reduced by installing in a certain location, it shall take precedent over the air device if relocation of the air device does not significantly affect HVAC system performance. Coordinate proposed diffusers/registers/grilles relocations with the Engineer.)
 12. Structural support components.
- E. When mounting heights of hung HVAC system components are not detailed or dimensioned in the HVAC Documents, install components to provide the maximum headroom possible.
1. Components in mechanical equipment rooms may be mounted lower to facilitate operation and maintenance. Bottom of any exposed component or support hanger shall be a minimum 7'-0" above the finished floor unless noted otherwise in the HVAC Documents.
 2. If any component must hang below 7'-0", all surfaces shall be covered with a brightly-colored, OSHA-approved, soft protective covering to prevent physical harm.
- F. Bid shall include sufficient fittings, material, and labor to allow for adjustment in routing of the HVAC systems made necessary by the coordination process.

1.13 INSPECTIONS

- A. Contact AHJ(s) and coordinate the requirements, timing, and completion of all required inspections.
- B. Do not enclose, cover, insulate, or put into operation any portion of the HVAC systems required by the AHJ to be inspected.
- C. Furnish all material, equipment, tools, temporary connections, labor, and services as required by the AHJ(s) to complete the inspection.
- D. If a portion of the HVAC system does not pass tests or inspections, make required corrections and arrange for re-inspection.

1.14 OBSERVATION OF THE WORK

- A. Site visits by the Engineer will consist of visual observations of the construction to permit the Engineers to render their professional opinion as to the Contractor's conformance to the intent of the HVAC Documents. Given the inherent limitations of such inspections, they cannot be relied upon by any party as acceptance of the work nor relieve any party from fulfillment of customary and contractual responsibilities/obligations.
- B. The Engineer does not have the right to reject work or the right/duty to stop work.
- C. Construction observation report(s) may recommend rejection of the work which, in the Engineer's professional opinion, does not conform to the intent of the HVAC Documents or applicable Code requirements .
- D. The fact that the Engineer has failed to observe and/or documented work that is faulty or is not in accordance with the HVAC Documents does not relieve the Contractor from the responsibility of correcting such work.
- E. Although the Engineer may confer on site with the Contractor regarding interpretation of the plans and specifications, such assistance does not relieve the Contractor of any responsibility from performing all required work.
- F. The Engineer does not have the right to change the requirements of the Contract Documents in any way. Any statements made by the Engineer regarding their opinion on the suitability of any Contractor proposed modifications of the plans and specifications shall not be interpreted by anyone as an authorization to change the requirements of the Contract Documents. All Contractor proposed changes to the Contract Documents shall be made to and accepted by the Architect in writing in accordance with the procedures as stated in Division 1.
- G. Compliance with OSHA requirements or other statutory safety requirements is the complete responsibility of the Contractor.

- H. Prior to the Engineer's final construction observation (for all or any portion of the Project), the Contractor shall provide the Engineer with the Contractor's observation report that was made prior to the Engineer's visit.
 - 1. Provide a set of mechanical drawings that have been used by the Contractor to verify the installation of all components. Verified items must be highlighted. Drawings must include floor plans, risers, and details that indicate all required components.

1.15 GUARANTEE/WARRANTY

- A. Guarantee that the installed HVAC systems are fully coordinated, complete, and properly functioning as outlined in the HVAC documents. This shall include, but not be limited to, the following:
 - 1. Any defects due to faulty workmanship or material.
 - 2. All raceways are free from foreign material, obstructions, holes or breaks of any nature.
 - 3. Ducted air systems have proper airflow.
 - 4. All equipment is fully functioning to the intent of their sequence of operation.
 - 5. All piping systems have proper circulation.
- B. Upon written notice from the Architect or Owner, promptly remedy any defects occurring within the Project's Base Warranty Period from the date as specified by the Architect.
- C. Contractor is personally responsible to replace any equipment or portion of that equipment whose manufacturer's warranty is based on "time from shipment" which has expired prior to the end of the Project's Base Warranty Period or any specified special warranty period(s). Extended manufacturer's warranties may be utilized to provide coverage for the required warranty period(s) and shall be included in the Contractor's Bid.
- D. The Project's Base Warranty Period does not supersede any extended warranty periods hereinafter specified.

1.16 PROJECT CLOSEOUT

- A. Closeout Procedures, Project Record Documents, and Operation and Maintenance Data shall be in accordance with Division 1 and as hereinafter specified.
- B. Furnish Record Drawings showing all changes (whether generated by addenda, submittals, change orders, implemented request for information, field discovered condition, or construction coordination) in construction from that shown on the original Contract Documents in the manner as specified in Division 1.
- C. At the front of the HVAC portion of the Operation and Maintenance Data, provide a typed Installer's Information List including the General Contractor and any Sub-Contractors who performed part of the HVAC Systems installation. Paper page shall be inserted in a heavyweight, non-glare, plastic sheet protector or the information can be printed on a piece of 8.5"x11" card stock with holes punched for binding as specified in Division 1. Information for each contractor shall include:
 - 1. Name of Company.
 - 2. Company Address.
 - 3. Company Phone Number.
 - 4. Company Email Address.
 - 5. Contact Person in Company with their specific Phone Number and Email Address.
 - 6. Portion of work performed by Company with reference to Specification Section(s) and Drawing Number(s).
- D. HVAC portion of the Operation and Maintenance Data shall include:
 - 1. Installer's Information List.
 - 2. All equipment and specialties furnished under Division 23 shall have the following grouped together in accordance with Division 1 requirements.
 - a. A clean copy of all approved shop drawings marked definitively and legibly with all changes (whether generated by addenda, change orders, or field discovered condition, etc.) in equipment from those shown on the original contract documents.
 - b. Manufacturer's Installation, Operation, & Maintenance (I/O/M) Instructions/Manual(s).

- c. Manufacturer's parts list if not included in the I/O/M Instructions/Manual(s).
- d. Manufacturer's recommended maintenance clearances if not included in the I/O/M Instructions/Manual(s).
- e. Any other Manufacturer's printed data that would help the Owner in operating, maintaining, or modifying the installed system in the future.
- f. Copy of all Warranties.
- g. A copy of the final Test and Balance Report.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR MATERIAL AND EQUIPMENT

- A. All acceptable manufacturers listed for each item are completely subject to all requirements listed in the HVAC Documents for that item.
- B. Basis of Design manufacturers and model numbers used in the HVAC Documents establish the type and basic quality required. Products shall be provided with:
 - 1. All standard devices/accessories/features as indicated in the latest edition of the manufacturer's catalog/brochure/website published at the date of the Bid.
 - 2. Any options or modifications as stated in the HVAC Documents.
 - 3. As required or modification for its proper installation or obvious intended use.
- C. All HVAC components shall comply with the following:
 - 1. Manufactured by a company in the everyday business of producing that item.
 - 2. New (not previously used or re-manufactured), of the best quality, and free from defects.
 - 3. Have a minimum pressure rating equal to or greater than the system operating pressure.
- D. Each type of HVAC component shall be manufactured by a single company and obtained from one wholesaler/supplier.
 - 1. Exception: Commodity items.
- E. All equipment provided for the Project shall meet or exceed all minimum values and shall not exceed all maximum values indicated in the HVAC Documents.
- F. All equipment and systems shall be coordinated with all other associated equipment and systems.
- G. All material and equipment cannot contain any asbestos, lead, mercury, mercury compounds, urea-formaldehyde resin, or other EPA-recognized hazardous material of any kind or form.
- H. All equipment shall be equipped with warning and information signs and labels in accordance with ANSI Z35.1.
- I. Pipe and fittings shall be of nominal diameter as designated, with inner/outer surfaces concentric, smooth inside, straight, and free from weld flaws, blisters or other defects.
- J. Each length of pipe and each fitting shall have cast, stamped or indelibly marked on it the maker's mark or name and the weight and quality of the product where such marking is required by the approved standard that applies.
- K. Surface-Burning Characteristics:
 - 1. All HVAC system materials and components shall be noncombustible or listed/ labeled by a NRTL recognized by the AHJ, indicating that they do not exceed the required flame-spread/smoke-developed index when tested in accordance with ASTM E84 or UL 723.
 - 2. Interior: Flame-spread index of not more than 25 and a smoke-developed index of not more than 50
 - 3. Exterior: Flame-spread index of not more than 75 and a smoke-developed index of not more than 150.
 - 4. Required flame-spread/smoke-developed index shall be indicated on a list of materials/components or their shipping cartons.

2.02 SUSTAINABILITY REQUIREMENTS

- A. For field applications of adhesives, mastics, paint, or other material that are in the interior of the building, the VOC content cannot be greater than the requirements specified in Division 01 - Sustainable Design Requirements section(s)

2.03 DIELECTRIC FITTINGS

- A. General Requirements:
 - 1. Assembly of copper alloy and ferrous materials with separating nonconductive insulating material.
 - 2. End connections compatible with pipes to be joined.
- B. Dielectric Flange Insulating Kit consisting of non-conducting materials for field assembly of companion flanges will include:
 - 1. Pressure Rating: Minimum 150 psig.
 - 2. Gasket: Neoprene or phenolic.
 - 3. Bolt Sleeves: Phenolic or polyethylene.
 - 4. Bolt Washers: Phenolic with steel backing washers.
- C. Dielectric Couplings:
 - 1. Galvanized steel body.
 - 2. Pressure Rating and Temperature: Minimum 300 psig at 225 deg F .
 - 3. Lining: Inert and noncorrosive, thermoplastic .
- D. Dielectric Nipples:
 - 1. Standard: Comply with IAPMO PS 66.
 - 2. Electroplated steel body complying with ASTM F 1545.
 - 3. Pressure Rating and Temperature: Minimum 300 psig at 225 deg F .
 - 4. Lining: Inert and noncorrosive, propylene.

2.04 PIPE ESCUTCHEONS

- A. Manufactured escutcheons with a center opening diameter to closely fit around bare or insulated pipe with an outside diameter that completely covers penetration opening.
- B. Steel, IPS 1/4 – 10 inches and CPS 3/8 – 4 inches: Split-face type with spring-closed concealed hinge, locking tabs, set screw or spring clips, and chrome-plated finish.

2.05 PIPE PENETRATION ROOF CURB

- A. Single-Point, Multiple Pipe/Conduit Roof Curb:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pate
 - b. Portals Plus.
 - c. Roof Products and Systems (RPS).
 - d. Thybar.
 - e. Approved manufacturer.
 - 2. Roof curb will be constructed of minimum 18-gauge galvanized steel with continuously welded corners and 1-1/2 inches, 3 lb. rigid fiberglass insulation on all sides. Minimum 12x12 inches exterior horizontal dimensions. Coordinate height as follows:
 - a. For roofs with insulation installed above the roof structure, minimum 11 inches tall with factory-installed wood nailer and straight sides.
 - b. For roofs with insulation installed below the roof structure, minimum 8 inches tall with factory-installed wood nailer and bottom canted sides.
 - 3. Curb's top closure will be a single, laminated, acrylic coated, UV-stabilized ABS plastic piece sealing the top of the curb watertight and including one (1) or more 8 inch round collared opening(s) all with two (2) integral, molded sealing rings.
 - 4. Rubber top cap to be pressure-sealed watertight to the top of the curb's top closure piece.
 - a. Compression molded of Ethylene Propylene Diene Monomer (EPDM) synthetic rubber compounded to resist degradation due to oxidation, ozone exposure, and ultraviolet ray exposure.
 - b. Serviceable temperature range of at least -60 deg F to 270 deg F.
 - c. Two (2) grooves molded to the inside of the cap to mate to the metal curb's two sealing rings.

- d. Have a minimum of four (4) stepped pipe nipples per cap. Coordinate combination of nipple sizes to provide watertight seal around the penetrating pipes/conduits.
- 5. Stainless steel, screw-closing pipe clamps sized for each pipe nipple.
- 6. At the Contractor's option, utilize a minimum 8 inch diameter pipe/conduit roof curb in lieu of the square curb specified above. Curb will be constructed of minimum 0.06 inch spun aluminum with a 14 inches diameter base. The upper opening shall have two (2) beaded sealing rings roll formed into the metal. Pipe/conduit curb will be Portals Plus Alumi-Flash System or approved equivalent. Coordinate height as follows:
 - a. For roofs with insulation installed above the roof structure, minimum 13 inches tall.
 - b. For roofs with insulation installed below the roof structure, minimum 4 inches tall.

2.06 WOOD STUD GUARDS, SHIELDS, AND STUD SHOES

- A. Minimum 16 gauge steel plates shall be the full width of the stud(s) and a minimum of 6 inches tall or taller as required for horizontal piping thru wood studs or vertical piping thru wood plates.

PART 3 EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store and handle all HVAC components in accordance with manufacturer's recommendations.
- B. While temporarily storing HVAC components, do not exceed the structural capacity of the floor.
- C. Items intended for indoor installation cannot be stored exposed to outdoor weather conditions.
- D. Any HVAC component that can be damaged by water shall be protected from direct contact with rain, sprayed water, runoff, standing water, or any other type of moisture that will soak into or corrode the component. Items that have absorbed water or have been prematurely corroded cannot be utilized on the Project.
- E. Any HVAC component that can be damaged by direct sunlight shall be protected.
- F. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent damage and entrance of dirt, debris, and moisture.
- G. Maintain any factory-applied protective coatings during construction until removal is required for system testing or final cleaning.
- H. Any HVAC component that has been damaged during delivery, storage, or construction before final acceptance by the Owner shall be repaired or replaced to return the item to a "like new" condition in a manner approved by the Architect.
 - 1. Repair: This method may be used if a HVAC item can be repaired by field correcting or replacing the damaged component of that item without affecting the item's warranty, service life, construction integrity, or visual appearance. All work shall be done in strict accordance with the manufacturer's instructions, requirements, and/or supervision.
 - 2. Replace: This method shall be used if, in the Architects opinion, the damage is too great to warrant a simple repair, the appearance of the item cannot be returned to a state where the original damage cannot be detected, or if the damage/repair voids any portion of the items warranty.

3.02 EARTHWORK

- A. Comply with requirements in Division 31 "Earth Moving" for excavating, backfilling, and compaction of utility trenches for all below slab or grade HVAC piping or ducts.

3.03 GENERAL INSTALLATION REQUIREMENTS

- A. All work shall be done in a professional manner and appearance acceptable to the Architect.
- B. Installation shall be performed in a manner as required by the most stringent of the following:
 - 1. The Mechanical Code referenced in the Architectural Code Review portion of the Contract Documents.
 - 2. As required by the HVAC Documents.
 - 3. Ducts: Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) requirements.

4. General piping: American Society of Testing and Material (ASTM) requirements.
 5. Copper pipe: Copper Development Association (CDA) requirements.
 6. Steel pipe: American Society of Mechanical Engineers (ASME) requirements.
 7. Equipment, specialties, manufactured fittings, and specialized piping types: Manufacturer's requirements.
- C. Inspect and verify that all conditions affecting the work are acceptable before beginning installation of the HVAC systems.
- D. Notify the Architect as specified in Division 1 before proceeding with the work if a conflict arises between the work under this Section and other work.
- E. Do not proceed with the installation until unacceptable conditions are corrected.
- F. Piping or ducts cannot be installed through any solid structural component unless approved in writing by the Architect and Structural Consultant prior to the installation. Piping and ducts may be routed thru the open web of steel/wood bar-joists or trusses.
- G. Install piping and ducts in concealed locations except for the following locations:
1. If noted or shown to be exposed in finished areas on the drawings.
 2. Spaces without ceilings.
 3. Equipment rooms.
 4. Service areas.
- H. Installation of piping or ducts shall conform to the following requirements.
1. Be free of sags and bends.
 2. Be at right angles or parallel to building walls and other piping or ducts. Diagonal runs are prohibited above grade unless specifically indicated otherwise.
 3. Utilize fittings for all changes in direction, branch connections, and size changes.
 4. Permit the best accessibility for valve/damper operation and servicing.
 5. Connect to equipment and specialties with a means of mechanical disconnection to allow removal of the HVAC component with minimum or no pipes, ducts, or specialties removal.
 6. Cannot block maintenance or service access to HVAC components or any other building system component or equipment.
 7. Allow insulation to be installed and properly sealed completely around individual pipes or ducts.
 8. Allow sufficient space for ceiling panel removal above lay-in ceilings.
- I. Installation of HVAC equipment and specialties shall conform to the following requirements.
1. Be in accordance with the manufacturer's recommendations (including technical manuals, guides, bulletins, or submittals), in compliance with all Codes and referenced standards, and as required by the Contract Documents; whichever is more stringent. If the more stringent requirement(s) conflicts with the manufacturer's recommendation, bring the conflict to the Architect's attention as specified in Division 1 for clarification prior to installation.
 2. Be level, plumb, and parallel/perpendicular to the building structure and other building systems' components unless otherwise indicated.
 3. Be positioned to facilitate service, maintenance, repair, or replacement of the equipment or one of its components.
 4. Allow maximum possible headroom unless specific mounting heights are indicated.
 5. Allow right of way for piping installed at required slope.
 6. All floor-mounted equipment shall be mounted on concrete housekeeping pads. Metal legs, skids or bases that are part of the equipment are not adequate.

3.04 SUSTAINABILITY REQUIREMENT

- A. Perform all work in a manner as required in Division 1.

3.05 MISCELLANEOUS CONSTRUCTION COORDINATION

- A. Coordinate and arrange for spaces, chases, slots, sleeves, dampers, and openings in the building structure and general construction during the progress of the Project to allow for HVAC systems installations.

- B. Coordinate installation of required supporting devices.
- C. Access Doors: Coordinate size and location requirements for doors providing access to HVAC equipment and specialties requiring maintenance or periodic inspection which are concealed behind non-removable finished building surfaces. Minimum size of access door openings shall be as follows, or greater, as required for HVAC component maintenance or removal.
Coordinate exact sizes with the Architect.
 - 1. One-Hand or Inspection Access: 8 by 6 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 12 inches.
 - 4. Body Access: 24 by 18 inches.
 - 5. Body plus Ladder Access: 24 by 24 inches.

3.06 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and specialties assemblages.
 - 1. Not required for bronze or brass specialties installed in copper or stainless-steel pipe systems.
- B. 2 NPS and smaller: Use dielectric nipples or couplings.
- C. 2-1/2 NPS and larger: Use dielectric flange kits or couplings.

3.07 PIPE ESCUTCHEON INSTALLATION

- A. Install escutcheons for exposed pipe penetrations of walls and ceilings in finish spaces.
- B. Escutcheons for any type of pipe or conduit penetration of a fire or smoke walls shall be metal type.
- C. All visible escutcheons in a single space shall be of the same type as approved by the Architect.
- D. Insulated pipes: Interior dimension of escutcheon shall closely match exterior dimension of insulation.
 - 1. For metal escutcheons, neatly and professionally provide a non-combustible spacer between insulation and the escutcheon or securely fasten escutcheon to the wall/ceiling so the pipe is centered in the escutcheon.
- E. Escutcheons shall not be abutted to the adjoining surface until:
 - 1. Final finish of the adjoining wall or ceiling surface is complete.
 - 2. Installed firestopping at the pipe penetration has been inspected.

3.08 PIPE ROOF PENETRATION INSTALLATION

- A. Coordinate exact pipe roof penetrations locations with the structural and roofing systems being provided.
- B. Securely anchor pipe to the structure below the roof penetration.
- C. Single Pipe Penetrations: Watertight flashing and sealing of single pipe penetrations thru the roof shall be part of the roof waterproofing as specified in Division 7.
- D. Single-Point, Multiple Pipe/Conduit Roof Curb:
 - 1. Mount securely to the roof structural decking.
 - 2. For square curbs, coordinate with the roofing contractor to provide additional cants and/or crickets.
 - 3. If the structure slopes at more than 1/4 inch per foot, furnish/install a shim base under the entire base of the curb so that the top of the curb is level. Connection of the curb and shim to the structure shall be just as secure as the curb being directly connected to the structure.
 - 4. If the top of the finished roofing will be 6 inches or less from the top of the curb, furnish/install a base extension, under the entire base of the curb, to raise the prefabricated curb. Connection of the curb and base extension to the structure shall be just as secure as the curb being directly connected to the structure.

5. If an insulated pipe passes thru one of the pipe nipples, the nipple shall be securely clamped to the bare pipe. Pipe insulation shall be tightly butted to the bottom of the cap on the interior and to the top of the nipple on the exterior.
6. Fill the annular spaces in the curb with mineral fiber, flexible blanket type insulation completely from the top to the bottom of the curb. Utilize enough insulation to insure a permanent friction fit inside the curb.

3.09 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 for structural steel for HVAC systems.
- 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.

3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood 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.
- D. Install wood stud guards, shields, or stud shoes at all horizontal pipe penetrations in wood studs and all vertical penetrations of wood plates.

3.11 DAMAGE AND TOUCH-UP PAINTING

- A. Painting of HVAC systems, equipment, and components is specified in Division 09.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures as provided by the equipment manufacturer to match the original factory finish and in a manner/appearance acceptable to the Architect.

3.12 PROTECTION AND CLEANING

- A. Keep areas clear of debris during construction. Promptly remove waste material from premises.
- B. Clean all exposed HVAC components in finished and unfinished areas.
- C. Thoroughly clean both the accessible inside and the entire outside of all equipment.
- D. Take measures to protect completed areas and/or existing areas of the building from the migration of construction-generated contaminants.

END OF SECTION

**SECTION 23 05 13
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 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 1 - Motors and Generators 2021.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 SUBMITTALS

- A. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.

1.04 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.05 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.

1.06 WARRANTY

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

PART 2 PRODUCTS

2.01 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service:
 - 1. Motors 1 HP and Smaller: 115 volts, single phase, 60 Hz.
 - 2. Motors Larger than 1 Horsepower: 208 volts, three phase, 60 Hz.
- B. Construction:
 - 1. Open drip-proof type except where specifically noted otherwise.
 - 2. Design for continuous operation in 104 degrees F environment.
 - 3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
- C. 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.
- 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.

2.02 APPLICATIONS

- A. Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, and dust collection systems: Totally enclosed type.
- B. Motors located in outdoors, in wet air streams downstream of sprayed coil dehumidifiers, in draw through cooling towers, and in humidifiers: Totally enclosed weatherproof epoxy-treated type.
- C. Motors located outdoors and in draw through cooling towers: Totally enclosed weatherproof epoxy-sealed type.

2.03 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.
- C. Breakdown Torque: Approximately 200 percent of full load torque.
- D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
- E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.04 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.

2.05 SINGLE PHASE POWER - CAPACITOR START MOTORS

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

2.06 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- B. Starting Current: Six times full load current.
- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Comply with NEMA MG 1 for Design B motors.
- E. Insulation System: NEMA Class B or better.

- F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 29 13.
- I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- J. Sound Power Levels: To NEMA MG 1.
- K. Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- L. Nominal Efficiency: As indicated at full load and rated voltage when tested in accordance with IEEE 112.
- M. Nominal Power Factor: As indicated at full load and rated voltage when tested in accordance with IEEE 112.

2.07 ELECTRONICALLY COMMUTATED MOTORS (ECM)

- A. Applications:
 - 1. Commercial:
 - a. Roof Top Unit:
 - 1) Operating Mode: Constant speed.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the roof top unit and/or specified sequence of operation.
 - b. DX Fan Coil Unit:
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the DX fan coil unit and/or specified sequence of operation.
 - 3) Options: Remote mount control/User-Interface.
 - c. Desiccant dehumidification wheel:
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the energy recovery ventilator and/or specified sequence of operation.
 - 3) Options: Remote mount control.
 - d. Hydronic Pump:
 - 1) Operating Mode: Constant speed.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the hydronic pump and/or specified sequence of operation.
 - 2. Residential/Commercial:
 - a. Geothermal Heat Pumps:
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the geothermal heat pump and/or specified sequence of operation.

PART 3 EXECUTION

3.01 INSTALLATION

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

END OF SECTION

SECTION 23 05 17
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe sleeves.
- B. Manufactured sleeve-seal systems.

1.02 RELATED REQUIREMENTS

- A. Section 07 84 00 - Firestopping.
- B. Section 23 05 23 - General-Duty Valves for HVAC Piping.
- C. Section 23 05 53 - Identification for HVAC Piping and Equipment: Piping identification.
- D. Section 23 07 16 - HVAC Equipment Insulation.
- E. Section 23 07 19 - HVAC Piping Insulation.

1.03 REFERENCE STANDARDS

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

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.01 PIPE SLEEVES

- A. Manufacturers:
 - 1. Flexicraft Industries; Pipe Wall Sleeve: www.flexicraft.com/#sle.
- B. Plastic or Sheet Metal: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.

- C. 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.
- D. Penetrations in concrete beam flanges are permitted but are prohibited through ribs or beams without prior approval from the Architect.
- E. Clearances:
 - 1. Provide allowance for insulated piping.
 - 2. Wall, Floor, Floor, Partitions, and Beam Flanges: 1 inch greater than external; pipe diameter.
 - 3. All Rated Openings: Caulked tight with fire stopping material in compliance with ASTM E814 in accordance with Section 07 84 00 to prevent the spread of fire, smoke, and gases.

2.02 MANUFACTURED SLEEVE-SEAL SYSTEMS

- A. Manufacturers:
 - 1. Advance Products & Systems, LLC; Innerlynx: www.apsonline.com/#sle.
 - 2. Flexicraft Industries; PipeSeal: www.flexicraft.com/#sle.
- B. Modular/Mechanical Seal:
 - 1. Synthetic rubber interlocking links continuously fill annular space between pipe and wall/casing opening.
 - 2. Provide watertight seal between pipe and wall/casing opening.
 - 3. Elastomer element size and material in accordance with manufacturer's recommendations.
 - 4. Glass reinforced plastic pressure end plates.

PART 3 EXECUTION

3.01 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, partitions, and [_____]. 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 in compliance with ASTM C592.
 - b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
 - 3. All Rated Openings: Caulk tight with fire stopping material in compliance with ASTM E814 in accordance with Section 07 84 00 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.
- 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.

3.02 CLEANING

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

END OF SECTION

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**SECTION 23 05 19
METERS AND GAUGES FOR HVAC PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments 2022.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers 2014 (Reapproved 2020).
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers 2014 (Reapproved 2021).
- D. AWWA C700 - Cold-Water Meters -- Displacement Type, Metal Alloy Main Case 2020.
- E. UL 393 - Indicating Pressure Gauges for Fire-Protection Service Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.

1.04 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 POSITIVE DISPLACEMENT METERS (LIQUID)

- A. AWWA C700, positive displacement disc type suitable for fluid with metal alloy main case and cast iron frost-proof, breakaway bottom cap, hermetically sealed register, remote reading.

2.02 PRESSURE GAUGES

- A. Pressure Gauges: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
 - 1. Case: Steel with brass bourdon tube.
 - 2. Size: 4-1/2 inch diameter.
 - 3. Mid-Scale Accuracy: One percent.
 - 4. Scale: Psi and KPa.

2.03 PRESSURE GAUGE TAPPINGS

- A. Gauge Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Needle Valve: Brass, 1/4 inch NPT for minimum 150 psi.
- C. Syphon: Stainless Steel, 1/4 inch angle or straight pattern.

2.04 STEM TYPE THERMOMETERS

- A. Thermometers - Fixed Mounting: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish.
 - 1. Size: 9 inch scale.
 - 2. Window: Clear Lexan.
 - 3. Accuracy: 2 percent, per ASTM E77.

4. Calibration: Degrees F.
- B. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
 1. Size: 9 inch scale.
 2. Window: Clear Lexan.
 3. Accuracy: 2 percent, per ASTM E77.
 4. Calibration: Degrees F.

2.05 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2.06 TEST PLUGS

- A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with Viton core for temperatures up to 400 degrees F.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide one pressure gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.
- C. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide siphon on gauges in steam systems. Extend nipples and siphons to allow clearance from insulation.
- D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- E. Install thermometer sockets adjacent to controls system thermostat, transmitter, or sensor sockets. Refer to drawings.
- F. Coil and conceal excess capillary on remote element instruments.
- G. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- H. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- I. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- J. Locate test plugs where indicated.

3.02 SCHEDULE

- A. Positive Displacement Meters, Location:
 1. Expansion tank make-up.
 2. Cooling tower make-up.
- B. Pressure Gauges, Location and Scale Range:
 1. Pumps, 0 to 160 psi.
 2. Pressure tanks, 0 to 160 psi.
 3. Standpipe, highest points, 0 to 200 psi.
 4. Standpipe and sprinkler water supply connection, 0 to 200 psi.
 5. Sprinkler system, 0 to 200 psi.
 6. Pressure reducing valves, 0 to 160 psi.
 7. Backflow preventers, 0 to 160 psi.

- C. Pressure Gauge Tappings, Location:
 - 1. Control valves 3/4 inch & larger - inlets and outlets.
 - 2. Major coils - inlets and outlets.
 - 3. Heat exchangers - inlets and outlets.
 - 4. Chiller - inlets and outlets.
 - 5. Boiler - inlets and outlets.
- D. Stem Type Thermometers, Location and Scale Range:
 - 1. Heat exchangers - inlets and outlets, 0 to 250 degrees F.
 - 2. Boilers - inlets and outlets, 0 to 250 degrees F .
 - 3. Chiller - inlets and outlets, 0 to 100 degrees F.
- E. Thermometer Sockets, Location:
 - 1. Control valves 1 inch & larger - inlets and outlets.
 - 2. Reheat coils - inlets and outlets.
 - 3. Cabinet heaters - inlets and outlets.
 - 4. Unit heaters - inlets and outlets.
- F. Static Pressure and Filter Gauges, Location and Scale Range:
 - 1. Built up filter banks, .

END OF SECTION

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SECTION 23 05 23
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Applications.
- B. General requirements.
- C. Globe valves.
- D. Ball valves.
- E. Butterfly valves.
- F. Check valves.
- G. Gate valves.
- H. Chainwheels.

1.02 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. SWP: Steam working pressure.
- I. TFE: Tetrafluoroethylene.

1.03 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 2015.
- 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.
- 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 B31.1 - Power Piping 2022.
- H. ASME B31.9 - Building Services Piping 2020.
- I. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings 2004 (Reapproved 2019).
- J. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures 1999 (Reapproved 2022).
- K. ASTM A536 - Standard Specification for Ductile Iron Castings 1984, with Editorial Revision (2019).
- L. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings 2017.
- M. AWWA C606 - Grooved and Shouldered Joints 2015.
- N. MSS SP-67 - Butterfly Valves 2022.
- O. MSS SP-68 - High Pressure Butterfly Valves with Offset Design 2021.
- P. MSS SP-70 - Gray Iron Gate Valves, Flanged and Threaded Ends 2011.

- Q. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends 2018.
- R. MSS SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Service 2010a.
- S. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves 2019.
- T. MSS SP-85 - Gray Iron Globe and Angle Valves, Flanged and Threaded Ends 2011.
- U. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends 2010, with Errata .
- V. MSS SP-125 - Check Valves: Gray Iron and Ductile Iron, In-Line, Spring-Loaded, Center-Guided 2018.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.05 QUALITY ASSURANCE

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

1.06 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.
- C. Exercise the following precautions for handling:
 - 1. Handle large valves with sling, modified to avoid damage to exposed parts.
 - 2. Avoid the use of operating handles or stems as rigging or lifting points.

PART 2 PRODUCTS

2.01 APPLICATIONS

- A. Provide the following valves for the applications if not indicated on drawings:
 - 1. Throttling (Hydronic): Butterfly, and Ball.
 - 2. Isolation (Shutoff): Butterfly and Ball.
 - 3. Swing Check (Pump Outlet):
 - a. 2 NPS and Smaller: Bronze with bronze disc.

- b. 2-1/2 NPS and Larger: Iron with lever and weight, lever and spring, center-guided metal, or center-guided with resilient seat.
 - 4. Dead-End: Butterfly, single-flange (lug) type.
 - B. Substitutions of valves with higher CWP classes or SWP ratings for same valve types are permitted when specified CWP ratings or SWP classes are not available.
 - C. Required Valve End Connections for Non-Wafer Types:
 - 1. Steel Pipe:
 - a. 2 NPS and Smaller: Threaded ends.
 - b. 2-1/2 NPS and Larger: Grooved ends.
 - 2. Copper Tube:
 - a. 2 NPS and Smaller: Threaded ends (Exception: Solder-joint valve-ends).
 - b. 2-1/2 NPS and Larger: Grooved ends.
 - 3. Steam and Steam Condensate Pipe: Grooved ends not acceptable.
 - D. Chilled Water Valves:
 - 1. 2 NPS and Smaller, Brass and Bronze Valves:
 - a. Threaded ends.
 - b. Ball: Full port, two piece, brass trim.
 - c. Swing Check: Bronze disc, Class.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. 2-1/2 NPS to 4 NPS: Threaded ends.
 - b. Ball: 2-1/2 NPS to 10 NPS, Class 150.
 - c. Single-Flange Butterfly: 2-1/2 NPS to 12 NPS, aluminum-bronze disc, EPDM seat, 200 CWP.
 - d. Grooved-End Butterfly: 2-1/2 NPS to 12 NPS, 175 CWP.
 - e. Swing Check: Metal seats, Class 125.
 - f. Swing Check with Closure Control: 2-1/2 NPS to 12 NPS, lever and spring, Class 125.
 - g. Grooved-End Check: 3 NPS to 12 NPS, 300 CWP.
 - h. Center-Guided Check: Compact-wafer, metal seat, Class 125.
 - E. Heating Hot Water Valves:
 - 1. 2 NPS and Smaller, Brass and Bronze Valves:
 - a. Threaded ends.
 - b. Ball: Full port, two piece, brass trim.
 - c. Swing Check: Bronze disc, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. 2-1/2 NPS to 4 NPS: Threaded ends.
 - b. Ball: 2-1/2 NPS to 10 NPS, Class 150.
 - c. Single-Flange Butterfly: 2-1/2 NPS to 12 NPS, aluminum-bronze disc, EPDM seat, 200 CWP.
 - d. Grooved-End Butterfly: 2-1/2 NPS to 12 NPS, 175 CWP.
 - e. Swing Check: Metal seats, Class 125.
 - f. Swing Check: 2-1/2 NPS to 12 NPS, lever and spring closure control, Class 125.
 - g. Grooved-End Swing Check: 3 NPS to 12 NPS, 300 CWP.
 - h. Center-Guided Check: Compact-wafer, metal seat, Class 125.
 - F. Low Pressure Steam Valves (15 PSIG or Less):
 - 1. 2 NPS and Smaller, Brass and Bronze Valves:
 - a. Swing Check: Bronze disc, Class 125.
 - b. Globe: Bronze disc, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. 2-1/2 NPS to 4 NPS: Threaded or Flanged ends.
 - b. Butterfly: High performance, single flange, Class 150.
 - c. Swing Check: Metal seats, Class 125.
 - d. Swing Check: 2-1/2 NPS to 12 NPS, lever and spring closure. control, Class 125.

- e. Gate: NRS, Class 125.
- f. Globe: 2-1/2 NPS to 12 NPS: Class 125.
- G. Steam-Condensate Valves:
 - 1. 2 NPS and Smaller, Brass and Bronze Valves:
 - a. Globe: Bronze disc, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. Provide 2-1/2 NPS to 4 NPS with threaded or flanged ends.
 - b. Swing Check: Metal seats, Class 125.
 - c. Swing Check: Lever and spring closure control, Class 125.
 - d. Gate: NRS, Class 125.
 - e. Globe: 2-1/2 NPS to 12 NPS, Class 125.

2.02 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- B. Valve Sizes: Match upstream piping unless otherwise indicated.
- C. Valve Actuator Types:
 - 1. Gear Actuator: Quarter-turn valves 8 NPS and larger.
 - 2. Handwheel: Valves other than quarter-turn types.
 - 3. Hand Lever: Quarter-turn valves 6 NPS 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 NPS 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.
- E. Memory Stops: Fully adjustable after insulation is installed.
- F. Valve-End Connections:
 - 1. Threaded End Valves: ASME B1.20.1.
 - 2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
 - 3. Pipe Flanges and Flanged Fittings 1/2 NPS through 24 NPS: ASME B16.5.
 - 4. Solder Joint Connections: ASME B16.18.
 - 5. Grooved End Connections: AWWA C606.
- G. General ASME Compliance:
 - 1. Ferrous Valve Dimensions and Design Criteria: ASME B16.10 and ASME B16.34.
 - 2. Power Piping Valves: ASME B31.1.
 - 3. Building Services Piping Valves: ASME B31.9.
- H. Bronze Valves:
 - 1. Fabricate from dezincification resistant material.
 - 2. Copper alloys containing more than 15 percent zinc are not permitted.
- I. Source Limitations: Obtain each valve type from a single manufacturer.

2.03 BRONZE GLOBE VALVES

- A. Class 125: CWP Rating: 200 psig:
 - 1. Comply with MSS SP-80, Type 1.
 - 2. Body: Bronze; ASTM B62, with integral seat and screw in bonnet.
 - 3. Ends: Threaded.
 - 4. Stem and Disc: Bronze or PTFE.
 - 5. Packing: Asbestos free.

- a. Handwheel: Malleable iron.

2.04 IRON GLOBE VALVES

- A. Class 125: CWP Rating: 200 psig: and Class 250: CWP Rating: 500 psig:.
 - 1. Comply with MSS SP-85, Type I.
 - 2. Body: Gray iron; ASTM A126, with bolted bonnet.
 - 3. Ends: Flanged.
 - 4. Trim: Bronze.
 - 5. Packing and Gasket: Asbestos free.
 - 6. Operator: Handwheel or chainwheel.

2.05 BRASS BALL VALVES

- A. Two Piece, Full Port with Stainless Steel Trim:
 - 1. Comply with MSS SP-110.
 - 2. SWP Rating: 150 psig.
 - 3. CWP Rating: 600 psig.
 - 4. Body: Forged brass.
 - 5. Ends: Threaded.
 - 6. Seats: PTFE or TFE.
 - 7. Stem: Stainless Steel.
 - 8. Ball: Chrome-plated brass.

2.06 BRONZE BALL VALVES

- A. Two Piece, Full Port with Bronze or Brass Trim:
 - 1. Comply with MSS SP-110.
 - 2. SWP Rating: 150 psig.
 - 3. CWP Rating: 600 psig.
 - 4. Body: Bronze.
 - 5. Ends: Threaded.
 - 6. Seats: PTFE .
 - 7. Stem: Bronze or brass.
 - 8. Ball: Chrome plated brass.

2.07 IRON BALL VALVES

- A. Split Body, Full Port:
 - 1. Comply with MSS SP-72.
 - 2. CWP Rating: 200 psig.
 - 3. Body: ASTM A126, gray iron.
 - 4. Ends: Flanged.
 - 5. Seats: PTFE.
 - 6. Stem: Stainless steel.
 - 7. Ball: Stainless steel.

2.08 IRON, SINGLE FLANGE BUTTERFLY VALVES

- A. Lug type: Bi-directional dead end service without downstream flange.
 - 1. Comply with MSS SP-67, Type I.
 - 2. CWP Rating: 150 psig.
 - 3. Body Material: ASTM A126 cast iron or ASTM A536 ductile iron.
 - 4. Stem: One or two-piece stainless steel.
 - 5. Seat: NBR.
 - 6. Disc: Coated ductile iron.

2.09 IRON, GROOVED-END BUTTERFLY VALVES

- A. CWP Rating: 300 psig (2070 kPa): 8 NPS (50 DN) or smaller and 200 psig (1389 kPa): 10 NPS (250 DN) or larger.
 - 1. Comply with MSS SP-67, Type I.

2. Body: Coated ductile iron.
3. Stem: Stainless steel.
4. Disc: Coated ductile iron.
5. Disc Seal: EPDM.

2.10 HIGH-PERFORMANCE SINGLE FLANGE BUTTERFLY VALVES

- A. Lug type: Bi-directional dead end service without downstream flange.
 1. Comply with MSS SP-68.
 2. Class 150: CWP Rating: 285 psig and Class 300: CWP Rating: 720 psig at 100 degrees F.
 3. Body: Provide carbon steel, cast iron, ductile Iron, or stainless steel.
 4. Seat: Metal or reinforced PTFE.
 5. Offset stem: Stainless steel.
 6. Disc: Carbon steel.

2.11 BRONZE SWING CHECK VALVES

- A. Class 150: CWP Rating: 300 psig (2070 kPa).
 1. Comply with MSS SP-80, Type 3.
 2. Body Design: Horizontal flow.
 3. Body Material: Bronze, ASTM B62.
 4. Ends: Threaded.
 5. Disc: Bronze.

2.12 IRON, FLANGED END SWING CHECK VALVES

- A. Class 125: CWP Rating: 200 psig (1380 kPa) with Metal Seats.
 1. Comply with MSS SP-71, Type I.
 2. Design: Clear or full waterway with flanged ends.
 3. Body: Gray iron with bolted bonnet in accordance with ASTM A126.
 4. Trim: Bronze.
 5. Disc Holder: Bronze.
 6. Disc: PTFE.
 7. Gasket: Asbestos free.

2.13 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

- A. Class 125:
 1. Comply with MSS SP-71, Type I.
 2. 2-1/2 NPS to 12 NPS, CWP Rating: 200 psig.
 3. 14 NPS to 24 NPS, CWP Rating: 150 psig.
 4. Body Design: Clear or full waterway.
 5. Body Material: ASTM A126, gray iron with bolted bonnet.
 6. Ends: Flanged.
 7. Trim: Bronze.
 8. Gasket: Asbestos free.
 9. Closer Control: Factory installed, exterior lever, and spring or weight.

2.14 IRON, GROOVED-END SWING CHECK VALVES

- A. 300 CWP:
 1. 2 NPS to 8 NPS.
 2. 10 NPS to 12 NPS.
 3. CWP Rating: 300 psig.
 4. Body Material: ASTM A536, Grade 65-45-12 ductile iron.
 5. Seal: EPDM.
 6. Disc: Ductile iron.
 7. Coating: Black, non-lead paint.

2.15 IRON, CENTER-GUIDED CHECK VALVES

- A. Class 125, Compact-Wafer:
 - 1. Comply with MSS SP-125.
 - 2. 2-1/2 NPS to 12 NPS, CWP Rating: 200 psig.
 - 3. 14 NPS to 24 NPS, CWP Rating: 150 psig.
 - 4. Body Material: ASTM A126, gray iron.
 - 5. Resilient Seat: EPDM.

2.16 BRONZE GATE VALVES

- A. Non-Rising Stem (NRS) or Rising Stem (RS):
 - 1. Comply with MSS SP-80, Type I.
 - 2. Class 150: CWP Rating: 300 psig.
 - 3. Body Material: Bronze with integral seat and union-ring bonnet.
 - 4. Ends: Threaded.
 - 5. Stem: Bronze.
 - 6. Disc: Solid wedge; bronze.
 - 7. Packing: Asbestos free.
 - 8. Handwheel: Malleable iron, bronze, or aluminum.

2.17 IRON GATE VALVES

- A. OS & Y:
 - 1. Comply with MSS SP-70, Type I.
 - 2. Class 125: 2-1/2 NPS to 12 NPS, CWP Rating: 200 psig.
 - 3. Class 125: 14 NPS to 24 NPS, CWP Rating: 150 psig.
 - 4. Body Material: Gray iron with bolted bonnet.
 - 5. Ends: Flanged.
 - 6. Trim: Bronze.
 - 7. Disc: Solid wedge.
 - 8. Packing and Gasket: Asbestos free.

2.18 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 iron include zinc coating.
 - 4. Chain: Hot-dip galvanized steel. Sized to fit sprocket rim.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Provide unions or flanges with valves to facilitate equipment removal and maintenance while maintaining system operation and full accessibility for servicing.
- B. Provide separate valve support as required and locate valve with stem at or above center of piping, maintaining unimpeded stem movement.
- C. Install check valves where necessary to maintain direction of flow as follows:
 - 1. 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.

- D. Provide chainwheels on operators for valves 4 NPS and larger where located 96 NPS or more above finished floor, terminating 60 NPS above finished floor.

END OF SECTION

SECTION 23 05 29
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete: Concrete equipment pads.

1.02 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 2016a.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping 2022.
- 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 B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2023.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- H. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials 2022a.
- I. MFMA-4 - Metal Framing Standards Publication 2004.
- J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).
- K. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.

3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
4. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 1. Manufacturers:
 - a. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com/#sle.
 - b. Ferguson Enterprises Inc: www.fnw.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.
 - d. Unistrut, a brand of Atkore International Inc: www.unistrut.com/#sle.
 2. Provide factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 3. Comply with MFMA-4.
 4. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
 5. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch.
 6. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
- C. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
 1. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Piping up to 1 inch (27 mm) nominal: 1/4 inch diameter.
 - c. Piping larger than 1 inch (27 mm) nominal: 3/8 inch diameter.
- D. Steel Cable:
 1. Manufacturers:
 - a. Ductmate Industries, Inc, a DMI Company; Clutcher Cable Hanging System: www.ductmate.com/#sle.
- E. Thermal Insulated Pipe Supports:
 1. Manufacturers:
 - a. Aeroflex USA, Inc; Aerofix-U Pipe Supports: www.aeroflexusa.com/#sle.
 - b. KB Enterprises: www.snappitz.com/#sle.
 2. General Construction and Requirements:
 - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
 - b. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
 - c. Pipe supports to be provided for nominally sized, 1/2 inch to 30 inch iron pipes.
 - d. Insulation inserts to consist of polyisocyanurate (urethane) insulation surrounded by a 360 degree, PVC jacketing.
 3. PVC Jacket:
 - a. Pipe insulation protection shields to be provided with a ball bearing hinge and locking seam.
 - b. Minimum Service Temperature: Minus 40 degrees F.

- c. Maximum Service Temperature: 180 degrees F.
 - d. Moisture Vapor Transmission: 0.0071 perm inch, when tested in accordance with ASTM E96/E96M.
 - e. Thickness: 60 mil.
- F. Pipe Supports:
- 1. Liquid Temperatures Up To 122 degrees F:
 - a. Overhead Support: MSS SP-58 Types 1, 3 through 12.
 - b. Support From Below: MSS SP-58 Types 35 through 38.
 - 2. Operating Temperatures from 122 to 446 degrees F:
 - a. Overhead Support: MSS SP-58 Type 1 or 3 through 12, with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.
 - b. Roller Support: MSS SP-58 Types 41 or 43 through 46, with appropriate saddle of MSS SP-58 Type 39 for insulated pipe.
- G. Beam Clamps: MSS SP-58 Types 19 through 23, 25 or 27 through 30 based on required load.
- 1. Material: ASTM A36/A36M carbon steel or ASTM A181/A181M forged steel.
 - 2. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- H. Riser Clamps:
- 1. Manufacturers:
 - 2. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
- I. Offset Pipe Clamps: Double-leg design two-piece pipe clamp.
- J. Strut Clamps: Two-piece pipe clamp.
- K. Insulation Clamps: Two bolt-type clamps designed for installation under insulation.
- L. Pipe Hangers: For a given pipe run use hangers of the same type and material.
- 1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 - 2. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
- M. Intermediate Pipe Guides: Use pipe clamps with oversize pipe sleeve that provides clearance around pipe.
- 1. Pipe Diameter 6 inches and Smaller: Provide minimum clearance of 0.16 inch.
- N. Pipe Alignment Guides: Galvanized steel.
- 1. Pipe Diameter 8 inches and Smaller: Spider or sleeve type.
- 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.
- P. Non-Penetrating Rooftop Supports for Low-Slope Roofs:
- 1. Manufacturers:
 - a. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com/#sle.
 - b. Erico International Corporation, a brand of Pentair: www.erico.com/#sle.
 - c. Ferguson Enterprises Inc: www.fnw.com/#sle.
 - d. PHP Systems/Design: www.phpsd.com/#sle.
 - e. Unistrut, a brand of Atkore International Inc: www.unistrut.com/#sle.
 - 2. Provide steel pedestals with thermoplastic or rubber base 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.
 - 3. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - 4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
 - 5. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.

Q. Anchors and Fasteners:

1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
4. Hollow Masonry: Use toggle bolts.
5. Hollow Stud Walls: Use toggle bolts.
6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
7. Sheet Metal: Use sheet metal screws.
8. Plastic and lead anchors are not permitted.
9. Hammer-driven anchors and fasteners are not permitted.
10. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

PART 3 EXECUTION

3.01 INSTALLATION

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

END OF SECTION

**SECTION 23 05 33
HEAT TRACING FOR HVAC PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Self-regulating parallel resistance electric heating cable.

1.02 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.

1.03 SUBMITTALS

- A. Product Data: Provide data for electric heat tracing system.
- B. Manufacturer's Installation Instructions: Indicate installation instructions and recommendations.
- C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions of equipment and controls, maintenance and repair data, and parts listings.
- D. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with at least three years of documented experience.

1.05 WARRANTY

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

PART 2 PRODUCTS

2.01 SELF-REGULATING PARALLEL RESISTANCE ELECTRIC HEATING CABLE

- A. Manufacturers:
 - 1. Chromalox, Inc.
 - 2. Thermon Manufacturing Company.
 - 3. 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:
 - 1. Provide pair of parallel No. 16 tinned, tinned, or tinned 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.
- H. Maximum Power-Off Exposure Temperature: 185 degrees F.

2.02 OUTER JACKET MARKINGS

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

2.03 CONNECTION KITS

- A. Provide power connection, power connection, splice/tee, and splice/tee 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.

2.04 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.
 - 4. Cable ties.
 - 5. Silicone end seals and splice kits.
 - 6. Installation clips.
 - 7. Warning labels for attachment to exterior of piping insulation.

2.05 CONTROLS

- A. Thermostat for controlling freeze protection heat-tracing circuits in ordinary areas.
 - 1. NEMA 4X, UV resistant thermoplastic enclosure
 - 2. Set point: 40 DegF - fixed
 - 3. Includes SPST contactor
 - 4. Fluid-filled bulb and capillary

PART 3 EXECUTION

3.01 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.

3.02 PREPARATION

- A. Clean all surfaces prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer.

3.03 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 including cladding over each valve or other equipment that may require maintenance.

3.04 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. Test heating cable integrity with megohmmeter at the following intervals:
 - a. After installing the connection kits.
 - b. After the installation of thermal insulation onto the piping.

5. Measure voltage and current at each unit.
6. Controls:

3.05 PROTECTION

- A. Protect installed products from damage until Date of Substantial Completion.

END OF SECTION

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**SECTION 23 05 48
VIBRATION AND SEISMIC CONTROLS FOR HVAC**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vibration isolation requirements.
- B. Vibration-isolated equipment support bases.
- C. Vibration isolators.
- D. Vibration-isolated and/or seismically engineered roof curbs.

1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete.

1.03 REFERENCE STANDARDS

- A. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures Most Recent Edition Cited by Referring Code or Reference Standard.
- B. ASCE 19 - Structural Applications of Steel Cables for Buildings 2016.
- C. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications Most Recent Edition Cited by Referring Code or Reference Standard.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate selection and arrangement of vibration isolation and/or seismic control 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.
 - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

1.05 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification method for spring element load capacities.

PART 2 PRODUCTS

2.01 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. Equipment Isolation:

1. Equipment Type: AHU-1.
 - a. Location: Outdoor.
 - b. Approximate Weight: 20,000 pounds.
 - c. Mounting: Vibration-isolated structural steel base.
 - d. Base Depth: 4 inches.
 - e. Isolator Type (Non-Seismic Application): Restrained spring isolators.
 2. Equipment Type: AHU-2.
 - a. Location: Outdoor.
 - b. Approximate Weight: 10,000 pounds.
 - c. Mounting: Vibration-isolated structural steel base.
 - d. Base Depth: 4 inches.
 - e. Isolator Type (Non-Seismic Application): Restrained spring isolators.
- E. Piping Isolation:
1. Provide vibration isolators for piping supports:
 - a. Located in equipment rooms.
 - b. Located within 50 feet of connected vibration-isolated equipment and pressure-regulating valve (PRV) stations.
 - c. For piping over 2 inch located below or within 50 feet of noise-sensitive areas indicated.
 2. Suspended Piping, Non-Seismic Applications: Use resilient material isolator hangers, spring isolator hangers, or combination resilient material/spring isolator hangers.
 3. Floor-Mounted Piping, Non-Seismic Applications: Use open (unhoused) spring isolators.
 4. Use modular seal or approved resilient material where vibration-isolated piping penetrates building elements (e.g. walls, floors) arranged to prevent vibration transmission to structure.

2.02 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES

- A. Manufacturers:
1. Vibration-Isolated Equipment Support Bases:
 - a. Kinetics Noise Control, Inc: www.kineticsnoise.com/#sle.
 - b. Vibration Eliminator Company, Inc: www.veco-nyc.com/#sle.
- 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.
 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 concrete in accordance with Section 03 30 00.

2.03 VIBRATION ISOLATORS

- A. Manufacturers:
1. Vibration Isolators:
 - a. Kinetics Noise Control, Inc: www.kineticsnoise.com/#sle.
 - b. Mason Industries: www.mason-ind.com/#sle.
- B. General Requirements:
1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.
 2. Spring Elements for Spring Isolators:
 - a. Color code or otherwise identify springs to indicate load capacity.
 - b. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.
 - c. Designed to operate in the linear portion of their load versus deflection curve over deflection range of not less than 50 percent above specified deflection.

- d. Designed to provide additional travel to solid of not less than 50 percent of rated deflection at rated load.
 - e. Selected to provide designed deflection of not less than 75 percent of specified deflection.
 - f. Selected to function without undue stress or overloading.
- C. Vibration Isolators for Non-Seismic Applications:
- 1. Resilient Material Isolator Pads:
 - a. Description: Single or multiple layer pads utilizing elastomeric (e.g. neoprene, rubber) or fiberglass isolator material.
 - b. Pad Thickness: As required for specified minimum static deflection; minimum 0.25 inch thickness.
 - c. Multiple Layer Pads: Provide bonded, galvanized sheet metal separation plate between each layer.
 - 2. Resilient Material Isolator Mounts, Non-Seismic:
 - a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g. neoprene, rubber) or fiberglass isolator material; fail-safe type.
 - 3. Open (Unhoused) Spring Isolators:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) without a housing.
 - b. Furnished with integral leveling device for positioning and securing supported equipment.
 - 4. Housed Spring Isolators:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing.
 - b. Furnished with integral elastomeric snubbing elements, non-adjustable type, for limiting equipment movement and preventing metal-to-metal contact between housing elements.
 - c. Furnished with integral leveling device for positioning and securing supported equipment.
 - 5. Restrained Spring Isolators, Non-Seismic:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) within a metal housing designed to prevent movement of supported equipment above an adjustable vertical limit stop.
 - 6. Resilient Material Isolator Hangers, Non-Seismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing elastomeric (e.g. neoprene, rubber) or fiberglass isolator material for the lower hanger rod connection.
 - 7. Spring Isolator Hangers, Non-Seismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) in series with an elastomeric element for the lower hanger rod connection.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short circuiting of isolation.
 - 8. Combination Resilient Material/Spring Isolator Hangers, Non-Seismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing single or multiple free-standing, laterally stable steel spring(s) for the lower hanger rod connection and elastomeric (e.g. neoprene, rubber) or fiberglass isolator material for the upper hanger rod connection.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short circuiting of isolation.

PART 3 EXECUTION

3.01 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 and/or seismic relative displacements as indicated or as required.
- 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.

3.02 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect vibration isolation and/or seismic control components for damage and defects.
- C. Vibration Isolation Systems:
 - 1. Verify isolator static deflections.
 - 2. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- D. Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials 2017.

1.03 SUBMITTALS

- A. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- B. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- C. Product Data: Provide manufacturers catalog literature for each product required.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates.
- B. Air Terminal Units: Nameplates.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. Heat Transfer Equipment: Nameplates.
- F. Instrumentation: Tags.
- G. Major Control Components: Nameplates.
- H. Piping: Pipe markers.
- I. Pumps: Nameplates.
- J. Small-sized Equipment: Tags.
- K. Major Equipment: Nameplates.
- L. Tanks: Nameplates.
- M. Valves: Tags.
- N. Water Treatment Devices: Nameplates.

2.02 NAMEPLATES

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

2.03 TAGS

- A. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- B. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.04 PIPE MARKERS

- A. Color: Comply with ASME A13.1.

- 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. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.
- E. Color code as follows:
 - 1. Heating, Cooling, and Boiler Feedwater: Green with white letters.
 - 2. Toxic and Corrosive Fluids: Orange with black letters.
 - 3. Compressed Air: Blue with white letters.

PART 3 EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Degrease and clean surfaces in preparation for stenciling.

3.02 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Testing, adjustment, and balancing of air systems.
 - 1. Constant-volume air systems.
 - 2. Variable-air-volume systems.
 - 3. Multizone systems.
- B. Testing, adjustment, and balancing of hydronic, steam, and refrigerating systems. Kitchen hood airflow balancing.
- C. Space pressurization testing and adjusting.
- D. Measurement of final operating condition of HVAC systems.

1.02 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 2008, with Errata (2019).
- C. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing 2002.

1.03 SUBMITTALS

- A. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- B. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Submit to Architect.
 - 2. Include at least the following in the plan:
 - a. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - b. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - c. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - d. Final test report forms to be used.
 - e. Detailed step-by-step procedures for TAB work for each system and issue, including:
 - 1) Terminal flow calibration (for each terminal type).
 - 2) Diffuser proportioning.
 - 3) Branch/submain proportioning.
 - 4) Total flow calculations.
 - 5) Rechecking.
 - 6) Diversity issues.
 - f. Details of how TOTAL flow will be determined; for example:
 - 1) Air: Sum of terminal flows via control system calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations.
 - 2) Water: Pump curves, circuit setter, flow station, ultrasonic, etc.
 - g. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
 - h. Confirmation of understanding of the outside air ventilation criteria under all conditions.
 - i. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
 - j. Method of checking building static and exhaust fan and/or relief damper capacity.

- k. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
 - l. Procedures for formal deficiency reports, including scope, frequency and distribution.
- C. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
 - 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 both I-P (inch-pound) and SI (metric) units.
 - 6. Include the following on the title page of each report:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone number of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Architect.
 - g. Project Engineer.
 - h. Project altitude.
 - i. Report date.
- D. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 - 1. AABC (NSTSB), AABC National Standards for Total System Balance.
 - 2. SMACNA (TAB).
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
 - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 - 2. Having minimum of three years documented experience.
 - 3. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com/#sle; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.02 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine 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.

- C. Examine the approved submittals for HVAC systems and equipment.
- D. See "Design Data" Article in the Evaluations.
- E. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- F. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- G. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- H. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- I. Examine test reports specified in individual system and equipment Sections.
- J. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units; such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- L. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- O. Examine system pumps to ensure absence of entrained air in the suction piping.
- P. Examine operating safety interlocks and controls on HVAC equipment.
- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.
- R. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Fire and volume dampers are in place and open.
 - 8. Air coil fins are cleaned and combed.
 - 9. Access doors are closed and duct end caps are in place.
 - 10. Air outlets are installed and connected.
 - 11. Duct system leakage is minimized.
 - 12. Hydronic systems are flushed, filled, and vented.

13. Pumps are rotating correctly.
 14. Proper strainer baskets are clean and in place.
 15. Service and balance valves are open.
- S. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- T. Beginning of work means acceptance of existing conditions.

3.03 PREPARATION

- A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
- B. Prepare a TAB plan that includes strategies and step-by-step procedures.
- C. Complete system-readiness checks and prepare reports. Verify the following:
1. Permanent electrical-power wiring is complete.
 2. Hydronic systems are filled, clean, and free of air.
 3. Automatic temperature-control systems are operational.
 4. Equipment and duct access doors are securely closed.
 5. Balance, smoke, and fire dampers are open.
 6. Isolating and balancing valves are open and control valves are operational.
 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.04 ADJUSTMENT TOLERANCES

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

3.05 RECORDING AND ADJUSTING

- A. 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. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.
- D. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- E. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.06 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's and/or "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
1. Comply with requirements in ASHRAE 62.1, Section 7.2.2, "Air Balancing." Comply with requirements in ASHRAE 62.1, Section 7.2.2, "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."

3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.07 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.08 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 1. Measure total airflow.
 - a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
 2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. 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.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Report the cleanliness status of filters and the time static pressures are measured.
 4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
 5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 6. Obtain approval from Construction Manager or Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

7. 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.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 1. Measure airflow of submain and branch ducts.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.
 1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.09 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- 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.
- B. Pressure-Independent, Variable-Air-Volume Systems: 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. Remeasure 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. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance variable-air-volume systems the same as described for constant-volume air systems.
 2. Set terminal units and supply fan at full-airflow condition.
 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 4. Readjust fan airflow for final maximum readings.
 5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 7. 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 the outlets balanced for maximum airflow.
 8. 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.
- D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 3. Set terminal units at full-airflow condition.
 4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 5. Adjust terminal units for minimum airflow.
 6. Measure static pressure at the sensor.
 7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.10 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 1. Open all manual valves for maximum flow.
 2. Check liquid level in expansion tank.
 3. Check makeup water-station pressure gage for adequate pressure for highest vent.
 4. Check flow-control valves for specified sequence of operation, and set at indicated flow.

5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.11 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Construction Manager or Commissioning Authority and comply with requirements in Division 23 Section "Hydronic Pumps."
 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 - a. Monitor motor performance during procedures and do not operate motors in overload conditions.
 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 4. Report flow rates that are not within plus or minus 10 percent of design.
- B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
- C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
- D. Set calibrated balancing valves, if installed, at calculated presettings.
- E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 1. Determine the balancing station with the highest percentage over indicated flow.
 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 3. Record settings and mark balancing devices.
- H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
- J. Check settings and operation of each safety valve. Record settings

3.12 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.13 PROCEDURES FOR STEAM SYSTEMS

- A. Measure and record upstream and downstream pressure of each piece of equipment.
- B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
- C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- D. Check settings and operation of each safety valve. Record settings.
- E. Verify the operation of each steam trap.

3.14 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Measure air quantities at air inlets and outlets.
- D. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
- E. 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.
- F. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- G. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- H. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- I. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- J. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- K. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.
- L. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.
- M. On fan powered VAV boxes, adjust air flow switches for proper operation.

3.15 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 gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect system balance with automatic control valves fully open to heat transfer elements.
- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.

- F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.16 SCOPE

- A. Test, adjust, and balance the following:
1. Plumbing Pumps.
 2. Boiler Feedwater Pumps.
 3. HVAC Pumps.
 4. Water Tube Boilers.
 5. Air Cooled Water Chillers.
 6. Packaged Terminal Air Conditioning Units.
 7. Computer Room Air Conditioning Units.
 8. Air Handling Units.
 9. Fans.
 10. Air Filters.
 11. Air Terminal Units.
 12. Air Inlets and Outlets.

3.17 MINIMUM DATA TO BE REPORTED

- A. Electric Motors:
1. Manufacturer.
 2. Model/Frame.
 3. HP/BHP.
 4. Phase, voltage, amperage; nameplate, actual, no load.
- B. Pumps:
1. Identification/number.
 2. Manufacturer.
 3. Size/model.
 4. Design flow rate, pressure drop, BHP.
 5. Actual flow rate, pressure drop, BHP.
 6. Discharge pressure.
 7. Suction pressure.
 8. Total operating head pressure.
 9. Shut off, discharge and suction pressures.
 10. Shut off, total head pressure.
- C. Combustion Equipment:
1. Boiler manufacturer.
 2. Model number.
 3. Serial number.
 4. Firing rate.
 5. Overfire draft.
 6. Gas meter timing dial size.
 7. Gas pressure at meter outlet.
 8. Gas flow rate.
 9. Heat input.
 10. Ambient temperature.
 11. Percent combustion efficiency.
 12. Heat output.
- D. Air Cooled Condensers:
1. Identification/number.
 2. Manufacturer.
 3. Model number.
 4. Entering DB air temperature, design and actual.
 5. Leaving DB air temperature, design and actual.

- E. Chillers:
 - 1. Identification/number.
 - 2. Capacity.
 - 3. Model number.
 - 4. Evaporator entering water temperature, design and actual.
 - 5. Evaporator leaving water temperature, design and actual.
 - 6. Evaporator pressure drop, design and actual.
 - 7. Evaporator water flow rate, design and actual.
 - 8. Condenser entering water temperature, design and actual.
 - 9. Condenser pressure drop, design and actual.
 - 10. Condenser water flow rate, design and actual.
- F. Cooling Coils:
 - 1. Identification/number.
 - 2. Air flow, design and actual.
 - 3. Entering air DB temperature, design and actual.
 - 4. Entering air WB temperature, design and actual.
 - 5. Leaving air DB temperature, design and actual.
 - 6. Leaving air WB temperature, design and actual.
 - 7. Water flow, design and actual.
 - 8. Water pressure drop, design and actual.
 - 9. Entering water temperature, design and actual.
 - 10. Leaving water temperature, design and actual.
 - 11. Air pressure drop, design and actual.
- G. Heating Coils:
 - 1. Identification/number.
 - 2. Air flow, design and actual.
 - 3. Water flow, design and actual.
 - 4. Water pressure drop, design and actual.
 - 5. Entering water temperature, design and actual.
 - 6. Leaving water temperature, design and actual.
 - 7. Entering air temperature, design and actual.
 - 8. Leaving air temperature, design and actual.
 - 9. Air pressure drop, design and actual.
- H. Air Moving Equipment:
 - 1. Location.
 - 2. Manufacturer.
 - 3. Model number.
 - 4. Air flow, specified and actual.
 - 5. Return air flow, specified and actual.
 - 6. Outside air flow, specified and actual.
 - 7. Total static pressure (total external), specified and actual.
 - 8. Inlet pressure.
 - 9. Discharge pressure.
- I. Return Air/Outside Air:
 - 1. Identification/location.
 - 2. Design air flow.
 - 3. Actual air flow.
 - 4. Design return air flow.
 - 5. Actual return air flow.
 - 6. Design outside air flow.
 - 7. Actual outside air flow.
 - 8. Return air temperature.

9. Outside air temperature.
 10. Required mixed air temperature.
 11. Actual mixed air temperature.
- J. Exhaust Fans:
1. Location.
 2. Manufacturer.
 3. Model number.
 4. Air flow, specified and actual.
 5. Total static pressure (total external), specified and actual.
 6. Inlet pressure.
 7. Discharge pressure.
- K. Duct Traverses:
1. System zone/branch.
 2. Duct size.
 3. Area.
 4. Design velocity.
 5. Design air flow.
 6. Test velocity.
 7. Test air flow.
 8. Duct static pressure.
 9. Air temperature.
 10. Air correction factor.
- L. Duct Leak Tests:
1. Description of ductwork under test.
 2. Duct design operating pressure.
 3. Duct design test static pressure.
 4. Duct capacity, air flow.
 5. Maximum allowable leakage duct capacity times leak factor.
- M. Air Monitoring Stations:
1. Identification/location.
 2. System.
 3. Area.
 4. Design velocity.
 5. Design air flow.
 6. Test velocity.
 7. Test air flow.
- N. Flow Measuring Stations:
1. Identification/number.
 2. Location.
 3. Size.
 4. Manufacturer.
 5. Model number.
 6. Serial number.
 7. Design Flow rate.
 8. Design pressure drop.
 9. Actual/final pressure drop.
 10. Actual/final flow rate.
 11. Station calibrated setting.
- O. Terminal Unit Data:
1. Manufacturer.
 2. Type, constant, variable, single, dual duct.
 3. Identification/number.

4. Model number.
 5. Size.
 6. Minimum static pressure.
 7. Minimum design air flow.
 8. Maximum design air flow.
 9. Maximum actual air flow.
 10. Inlet static pressure.
- P. Air Distribution Tests:
1. Air terminal number.
 2. Room number/location.
 3. Terminal size.
 4. Design air flow.
 5. Test (final) air flow.

END OF SECTION

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SECTION 23 07 13 DUCT INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Duct insulation.
- B. Duct liner.
- C. Insulation jackets.

1.02 REFERENCE STANDARDS

- A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate 2014.
- B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric) 2014.
- C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2021.
- D. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form 2020a.
- E. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications 2013 (Reapproved 2019).
- F. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation 2014 (Reapproved 2019).
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- H. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials 2022a.
- I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2021.
- J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.04 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.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, documented experience and approved by manufacturer.

1.05 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.

1.06 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

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

2.02 GLASS FIBER, FLEXIBLE

- A. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. 'K' value: 0.36 at 75 degrees F, when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 1200 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- B. Vapor Barrier Jacket:
 - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 3. Secure with pressure sensitive tape.
- C. Vapor Barrier Tape:
 - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

2.03 GLASS FIBER, RIGID

- A. Insulation: ASTM C612; rigid, noncombustible blanket.
 - 1. 'K' Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent.
 - 4. Maximum Density: 8.0 lb/cu ft.
- B. Vapor Barrier Jacket:
 - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 3. Secure with pressure sensitive tape.
- C. Vapor Barrier Tape:
 - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.

2.04 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. 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.
 - 2. Maximum Service Temperature: 180 degrees F.
 - 3. Connection: Waterproof vapor barrier adhesive.
- B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.05 JACKETS

- A. Aluminum Jacket: ASTM B209 (ASTM B209M).
 - 1. Thickness: 0.016 inch sheet.
 - 2. Finish: Smooth.
 - 3. Joining: Longitudinal slip joints and 2 inch laps.
 - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
 - 5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
 - 6. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulated ducts conveying air below ambient temperature:
 - 1. Provide insulation with vapor barrier jackets.
 - 2. Finish with tape and vapor barrier jacket.
 - 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 - 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- D. Insulated ducts conveying air above ambient temperature:
 - 1. Provide with or without standard vapor barrier jacket.
 - 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- E. Ducts Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet above finished floor): Finish with canvas jacket sized for finish painting or aluminum jacket.
- F. Exterior Applications: Provide insulation with vapor barrier jacket. Cover with with calked aluminum jacket with seams located on bottom side of horizontal duct section.
- G. External Duct Insulation Application:
 - 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
 - 2. Secure insulation without vapor barrier with staples, tape, or wires.
 - 3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
 - 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
 - 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- H. 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 air flow. Increase duct size to allow for insulation thickness.

3.03 SCHEDULES

- A. Exhaust Ducts Within 10 ft of Exterior Openings:
 - 1. Flexible Glass Fiber Duct Insulation: 2 inches thick.
 - 2. Rigid Glass Fiber Duct Insulation: 2 inches thick.
- B. Outside Air Intake Ducts:
 - 1. Flexible Glass Fiber Duct Insulation: 3 inches thick.
 - 2. Rigid Glass Fiber Duct Insulation: 3 inches thick.
- C. Plenums:
 - 1. Flexible Glass Fiber Duct Insulation: 2 inches thick.
 - 2. Rigid Glass Fiber Duct Insulation: 2 inches thick.
- D. Ventilation Equipment Casings:
 - 1. Flexible Glass Fiber Duct Insulation: 2 inches thick.
 - 2. Rigid Glass Fiber Duct Insulation: 2 inches thick.
- E. Supply Ducts:
 - 1. Flexible Glass Fiber Duct Insulation: 2 inches thick.
 - 2. Rigid Glass Fiber Duct Insulation: 2 inches thick.
- F. Supply ducts After Terminal Boxes:
 - 1. Flexible Glass Fiber Duct Insulation: 2 inches thick.

2. Rigid Glass Fiber Duct Insulation: 2 inches thick.
- G. Ducts Exposed to Outdoors:
1. Rigid Glass Fiber Duct Insulation: 3 inches thick.

END OF SECTION

**SECTION 23 07 16
HVAC EQUIPMENT INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Equipment insulation.
- B. Flexible removable and reusable blanket insulation.
- C. Covering.
- D. Breeching insulation.

1.02 REFERENCE STANDARDS

- A. ASTM A666 - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar 2015.
- B. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate 2014.
- C. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric) 2014.
- D. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus 2019.
- E. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus 2021.
- F. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form 2020a.
- G. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation 2022.
- H. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications 2013 (Reapproved 2019).
- I. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) 2016.
- J. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation 2014 (Reapproved 2019).
- K. ASTM C1695 - Standard Specification for Fabrication of Flexible Removable and Reusable Blanket Insulation for Hot Service 2022.
- L. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- M. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials 2022a.
- N. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.03 SUBMITTALS

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

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum 2 years of experience.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

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

2.02 GLASS FIBER, FLEXIBLE

- A. Insulation: ASTM C553; flexible, noncombustible.
 - 1. K Value: 0.36 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- B. Vapor Barrier Jacket: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 2. Secure with self-sealing longitudinal laps and butt strips.
- C. Tie Wire: 0.048 inch stainless steel with twisted ends on maximum 12 inch centers.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.

2.03 FLEXIBLE REMOVABLE AND REUSABLE BLANKET INSULATION

- A. Insulation: ASTM C553 Type V; flexible, noncombustible.
 - 1. Comply with ASTM C1695.
 - 2. K Value: 0.37 at 100 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 - 3. Minimum Service Temperature: 32 degrees F.
 - 4. Maximum Service Temperature: 500 degrees F.
 - 5. Maximum Water Vapor Absorption: Less than 5.0 percent by weight.

2.04 GLASS FIBER, RIGID

- A. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.
 - 1. K Value: 0.25 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 - 2. Maximum Service Temperature: 850 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
 - 4. Maximum Density: 8.0 lb/cu ft.
- B. Vapor Barrier Jacket:
 - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 3. Secure with self-sealing longitudinal laps and butt strips.
- C. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.

2.05 CELLULAR GLASS

- A. Pipe and Tubing Insulation: ASTM C552, Type II, Grade 6.
 - 1. K Value: 0.35 at 100 degrees F.
 - 2. Service Temperature Range: From 250 degrees F to 800 degrees F.
 - 3. Water Vapor Permeability: 0.005 perm inch maximum per inch.
 - 4. Water Absorption: 0.5 percent by volume, maximum.
 - 5. Density: At least 6.12 lb/cu ft.
- B. Block Insulation: ASTM C552, Type I, Grade 6.
 - 1. K Value: 0.35 at 100 degrees F.
 - 2. Service Temperature: 800 degrees F, maximum.
 - 3. Water Vapor Permeability: 0.005 perm inch maximum per inch.
 - 4. Water Absorption: 0.5 percent by volume, maximum.
 - 5. Density: At least 6.12 lb/cu ft.

2.06 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. 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.
 - 2. Maximum Service Temperature: 220 degrees F.
 - 3. Connection: Waterproof vapor barrier adhesive.
- B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.07 JACKETS

- A. PVC Plastic:
 - 1. Jacket: Sheet material, off-white color.
 - a. Minimum Service Temperature: Minus 40 degrees F.
 - b. Maximum Service Temperature: 150 degrees F.
 - c. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil.
- B. Aluminum Jacket: ASTM B209 (ASTM B209M) formed aluminum sheet.
 - 1. Thickness: 0.016 inch sheet.
 - 2. Finish: Smooth.
 - 3. Joining: Longitudinal slip joints and 2 inch laps.
 - 4. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
- C. Stainless Steel Jacket: ASTM A666, Type 304 stainless steel.
 - 1. Thickness: 0.010 inch.
 - 2. Finish: Smooth.
 - 3. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

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

- H. For hot equipment containing fluids 140 degrees F or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
- I. For hot equipment containing fluids over 140 degrees F, insulate flanges and unions with removable sections and jackets.
- J. Fiber glass insulated equipment containing fluids above ambient temperature; provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
- K. Inserts and Shields:
 - 1. Application: Equipment 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between hangers and inserts.
 - 3. Insert Location: Between support shield and equipment and under the finish jacket.
 - 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert Material: Heavy density insulating material suitable for the planned temperature range.
- L. Finish insulation at supports, protrusions, and interruptions.
- M. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.
- N. Exterior Applications:
 - 1. Provide vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement.
 - 2. Cover with aluminum or stainless steel.
- O. Cover glass fiber insulation with metal mesh and finish with heavy coat of insulating cement.

3.02 SCHEDULE

- A. Heating Systems:
 - 1. Heat Exchangers/Converters:
 - 2. Hot Thermal Storage Tanks:
 - 3. Boiler Feed Water Storage Tanks:
 - 4. Steam Condensate Receivers:
 - 5. Condensate Tanks:
 - 6. Deaerators:
 - 7. Flue Gas Breeching:
- B. Cooling Systems:
 - 1. Pump Bodies:
 - 2. Air Separators:
 - 3. Expansion Tanks:
 - 4. Chiller Cold Surfaces (Not Factory Insulated):
 - 5. Cold Thermal Storage Tanks:
 - 6. Equipment Exposed to Freezing with Heat Tracing:

END OF SECTION

**SECTION 23 07 19
HVAC PIPING INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping insulation.
- B. Jackets and accessories.

1.02 REFERENCE STANDARDS

- A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate 2014.
- B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric) 2014.
- 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.
- D. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement 2007 (Reapproved 2019).
- E. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form 2020a.
- F. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation 2022a.
- G. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel 2008 (Reapproved 2018).
- H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- I. ASTM E96/E96M - Standard Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials 2022a.
- J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- B. Sustainable Design Submittals: Include Laboratory Test Reports indicating compliance with the requirements for low-emitting materials.
 - 1. Product Data for adhesives indicating VOC content.
 - 2. Product Data for coatings indicating VOC content.
 - 3. Product Data for sealants indicating VOC content.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum 3 years of experience.

1.05 DELIVERY, STORAGE, AND HANDLING

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

1.06 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

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

2.02 GLASS FIBER, RIGID

- A. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
 - 1. K Value: ASTM C177, = 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: $\geq$ 850 degrees F.
 - 3. Maximum Moisture Absorption: = 0.2 percent by volume with ASJ.*{font-family:"Arial";font-size:10pt;}img{max-width:300px;max-height:300px;width:225px;height:225px;}span {white-space:pre; }
- B. Vapor Barrier Jacket: All Service Jacket (ASJ) shall be constructed of white kraft paper with glass fiber yarn bonded to aluminized film backing complying with ASTM C 1136, Type 1 with a maximum moisture vapor transmission (when tested in accordance with ASTM E96/E96M) of 0.02 perm-inches.
- C. Vapor Barrier Lap Adhesive: Compatible with insulation.
- D. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.

2.03 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
 - 1. Minimum Service Temperature: Minus 40 degrees F.
 - 2. Maximum Service Temperature: 180 degrees F.
 - 3. Connection: Waterproof vapor barrier adhesive.
- B. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.04 JACKETS

- A. PVC Plastic.
 - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: 0 degrees F.
 - b. Maximum Service Temperature: 150 degrees F.
 - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil.
 - e. Connections: Brush on welding adhesive.
- B. Aluminum Jacket: ASTM B209 (ASTM B209M) formed aluminum sheet.
 - 1. Thickness: 0.016 inch sheet.
 - 2. Finish: Smooth.
 - 3. Joining: Longitudinal slip joints and 2 inch laps.
 - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.

- D. Insulated pipes conveying fluids below ambient temperature; insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- E. 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 mas
 - 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.
- F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- G. Glass fiber insulated pipes conveying fluids above ambient temperature.
 - 1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- H. Inserts and Shields:
 - 1. Application: Piping 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 3. Insert location: Between support shield and piping and under the finish jacket.
 - 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
- I. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with aluminum jacket.
- J. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping. Provide two coats of UV resistant finish for flexible elastomeric cellular insulation without jacketing.
- K. 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 thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.
- L. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.03 SCHEDULE

- A. Heating Systems:
 - 1. Glycol Heating Supply and Return:
 - 2. Low Pressure Steam Piping:
 - 3. Gravity Steam Condensate:
- B. Cooling Systems:
 - 1. Glycol Cooling Supply and Return:
 - 2. Refrigerant

END OF SECTION

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**SECTION 23 08 00
COMMISSIONING OF HVAC**

PART 1 GENERAL

1.01 SUMMARY

- A. This section covers the Contractor's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.
- B. The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Contractor's use.
- C. The entire HVAC system is to be commissioned, including commissioning activities for the following specific items:
 - 1. Control system.
 - 2. Major and minor equipment items.
 - 3. Piping systems and equipment.
 - 4. Ductwork and accessories.
 - 5. Terminal units.
 - 6. Variable frequency drives.
 - 7. Special Ventilation:
 - a. Steam hoods.
 - b. Room pressurization.
 - 8. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
- D. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

1.02 SUBMITTALS

- A. Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
- B. DRAFT Prefunctional Checklists and Functional Test Procedures for Control System: Detailed written plan indicating the procedures to be followed to test, checkout and adjust the control system prior to full system Functional Testing; include at least the following for each type of equipment controlled:
 - 1. System name.
 - 2. List of devices.
 - 3. Step-by-step procedures for testing each controller after installation, including:
 - a. Process of verifying proper hardware and wiring installation.
 - b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
 - c. Process of performing operational checks of each controlled component.
 - d. Plan and process for calibrating valve and damper actuators and all sensors.
 - e. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
 - 4. Copy of proposed log and field checkout sheets to be used to document the process; include space for initial and final read values during calibration of each point and space to specifically indicate when a sensor or controller has "passed" and is operating within the contract parameters.
 - 5. Description of the instrumentation required for testing.
 - 6. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the Commissioning Authority and TAB contractor for this determination.

- C. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.
- D. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:
 - 1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.
 - 2. Full as-built set of control drawings.
 - 3. Full as-built sequence of operations for each piece of equipment.
 - 4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
 - a. Floor.
 - b. Room number.
 - c. Room name.
 - d. Air handler unit ID.
 - e. Reference drawing number.
 - f. Air terminal unit tag ID.
 - g. Heating and/or cooling valve tag ID.
 - h. Minimum air flow rate.
 - i. Maximum air flow rate.
 - 5. Full print out of all schedules and set points after testing and acceptance of the system.
 - 6. Full as-built print out of software program.
 - 7. Electronic copy on disk of the entire program for this facility.
 - 8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
 - 9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
 - 10. Control equipment component submittals, parts lists, etc.
 - 11. Warranty requirements.
 - 12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
 - 13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
 - a. Sequences of operation.
 - b. Control drawings.
 - c. Points lists.
 - d. Controller and/or module data.
 - e. Thermostats and timers.
 - f. Sensors and DP switches.
 - g. Valves and valve actuators.
 - h. Dampers and damper actuators.
 - i. Program setups (software program printouts).
- E. Project Record Documents:
 - 1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
 - 2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.
- F. Draft Training Plan: In addition to requirements specified in Section 01 79 00, include:
 - 1. Follow the recommendations of ASHRAE Guideline 1.1.
 - 2. Control system manufacturer's recommended training.
 - 3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.

- G. Training Manuals:
 - 1. Provide three extra copies of the controls training manuals in a separate manual from the O&M manuals.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

- A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.
- B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSPECTING AND TESTING - GENERAL

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

1. With full pressure in the system, command valve closed.
 2. Use an ultra-sonic flow meter to detect flow or leakage.
- F. Deficiencies: Correct deficiencies and re-inspect or re-test, as applicable, at no extra cost to Owner.

3.03 TAB COORDINATION

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

3.04 CONTROL SYSTEM FUNCTIONAL TESTING

- A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of Contract Documents and the detailed Sequences of Operation documentation submittal.
- B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with Contract Documents.
- C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.
- D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
 1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
 2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.
- E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.
- F. Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
 1. Setpoint changing features and functions.
 2. Sensor calibrations.
- G. Demonstrate to the Commissioning Authority:
 1. That all specified functions and features are set up, debugged and fully operable.
 2. That scheduling features are fully functional and setup, including holidays.
 3. That all graphic screens and value readouts are completed.
 4. Correct date and time setting in central computer.
 5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
 6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no

- extra cost to Owner.
- 7. Power failure and battery backup and power-up restart functions.
- 8. Global commands features.
- 9. Security and access codes.
- 10. Occupant over-rides (manual, telephone, key, keypad, etc.).
- 11. O&M schedules and alarms.
- 12. Occupancy sensors and controls.
- 13. All control strategies and sequences not tested during controlled equipment testing.
- H. Perform and submit trend logging on the following using the control system, for minimum period of 5 days including one weekend, if the control points are monitored by the control system:
- I. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to Owner.

3.05 OPERATION AND MAINTENANCE MANUALS

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

3.06 DEMONSTRATION AND TRAINING

- A. Demonstrate operation and maintenance of HVAC system to Owner' personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.
- B. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.
- C. Provide classroom and hands-on training of Owner's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned. Provide the following minimum durations of training:
- D. TAB Review: Instruct Owner's personnel for minimum 2 hours, after completion of TAB, on the following:
 - 1. Review final TAB report, explaining the layout and meanings of each data type.
 - 2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
 - 3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
 - 4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
 - 5. Other salient information that may be useful for facility operations, relative to TAB.
- E. HVAC Control System Training: Perform training in at least three phases:
 - 1. Phase 1 - Basic Control System: Provide minimum of 2 hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
 - a. This training may be held on-site or at the manufacturer's facility.
 - b. If held off-site, the training may occur prior to final completion of the system installation.
 - c. For off-site training, Contractor shall pay expenses of up to two attendees.

2. Phase 2 - Integrating with HVAC Systems: Provide minimum of 4 hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
 - a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
 - b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
 - c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends; provide practice in setting up trend logging and monitoring during training session.
 - d. Every display screen, allowing time for questions.
 - e. Point database entry and modifications.
 3. Phase 3 - Post-Occupancy: Six months after occupancy conduct minimum of 4 hours of training. Tailor training session to questions and topics solicited beforehand from Owner. Also be prepared to address topics brought up and answer questions concerning operation of the system.
- F. Provide the services of manufacturer representatives to assist instructors where necessary.
- G. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

END OF SECTION

SECTION 23 09 13
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Control panels.
- B. Control Valves:
 - 1. Globe pattern.
 - 2. Butterfly pattern.
 - 3. Electronic operators.
 - 4. Radiation valves.
- C. Dampers.
- D. Damper Operators:
 - 1. Electric operators.
- E. Humidistats:
 - 1. Room humidistats.
 - 2. Limit duct humidistats.
- F. Input/Output Sensors:
 - 1. Temperature sensors.
 - 2. Humidity sensors.
 - 3. Static pressure (air pressure) sensors.
 - 4. Equipment operation (current) sensors.
 - 5. Digital to pneumatic transducers.
 - 6. Damper position indicators.
 - 7. Nitrogen dioxide sensors.
 - 8. Carbon monoxide sensors.
 - 9. Carbon dioxide sensors.
- G. Thermostats:
 - 1. Electric room thermostats.
 - 2. Line voltage thermostats.
 - 3. Room thermostat accessories.
 - 4. Outdoor reset thermostats.
 - 5. Immersion thermostats.
 - 6. Airstream thermostats.
 - 7. Electric low limit duct thermostats.
 - 8. Electric high limit duct thermostats.
 - 9. Fire thermostats.
 - 10. Heating/cooling valve top thermostats.
- H. Time clocks.
- I. Transmitters:
 - 1. Building static pressure transmitters.
 - 2. Pressure transmitters.
 - 3. Air pressure transmitters.
 - 4. Water pressure transmitters (liquid differential pressure transmitters).
 - 5. Temperature transmitters.
 - 6. Humidity transmitters.
- J. Transducers:
 - 1. Electropneumatic transducers.
- K. Flow Sensors:
 - 1. Venturi tubes.
 - 2. Airflow measurement array (AFMA).

3. Annular pitot tubes.
 4. Orifice plates.
 5. Ultrasonic flow meters.
 6. Vortex shedding flow meters.
 7. Gas flow meters.
 8. Flow switches.
- L. Level Instruments:
1. Submersible level transmitters (Liquids other than potable water).
 2. Flush tip submersible level transmitters.
 3. Submersible level transmitters (potable water).
 4. Compact visual level indicators.
- M. Level Switches:
1. Capacitive Sensors:
 - a. Capacitance level switch.
 - b. Capacitive level switch.
 2. Conductivity Sensors:
 - a. Dual point level switch.
 - b. Conductivity controller.
 - c. Conductivity level probe.
 3. Float Sensors:
 - a. Float switch.
 - b. Liquid level switch.
 - c. Multi-level switch kit.
 - d. Insertion type level control.
 - e. Boiler water level control.
 4. Optical Sensors:
 - a. Optical level switch.

1.02 REFERENCE STANDARDS

- A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating 2018.
- B. ASME B1.20.1 - Pipe Threads, General Purpose, Inch 2013 (Reaffirmed 2018).
- C. IEC 60529 - Degrees of Protection Provided by Enclosures (IP Code) 1989 (Corrigendum 2019).
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- E. NEMA DC 3 - Residential Controls - Electrical Wall-Mounted Room Thermostats 2013.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- G. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

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

1.04 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. Manufacturer's Instructions: Provide for all manufactured components.
- D. Designer's Qualification Statement.
- E. Manufacturer's Qualification Statement.
- F. Installer's Qualification Statement.
- G. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.
- H. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.
 - 1. Revise shop drawings to reflect actual installation and operating sequences.
- I. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

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

1.06 WARRANTY

- A. Correct defective work within a five year period after Substantial Completion.

PART 2 PRODUCTS

2.01 EQUIPMENT - GENERAL

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

2.02 CONTROL PANELS

- A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gauges, pilot lights, push buttons and switches flush on cabinet panel face.
- B. NEMA 250, general purpose utility enclosures with enameled finished face panel.
- C. Provide common keying for all panels.

2.03 CONTROL VALVES

- A. Globe Pattern:
 - 1. Up to 2 inches: Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.
 - 2. Over 2 inches: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
 - 3. Hydronic Systems:
 - a. Rate for service pressure of 125 psig at 250 degrees F.
 - b. Replaceable plugs and seats of stainless steel.
 - c. Size for 3 psig maximum pressure drop at design flow rate.
 - d. two-way valves shall have equal percentage characteristics, three way valves linear characteristics. Size two-way valve operators to close valves against pump shut off head.
 - 4. Steam Systems:
 - a. Rate for service pressure of 125 psig at 250 degrees F.
 - b. Replaceable plugs and seats of stainless steel. Pressure drop across any steam valve at maximum flow; as indicated on drawings.
 - c. Size for 10 psig inlet pressure and 5 psig pressure drop.
 - d. Valves shall have modified linear characteristics.
- B. Butterfly Pattern:

1. Iron body, bronze disc, resilient replaceable seat for service to 180 degrees F wafer or lug ends, extended neck.
2. Hydronic Systems:
 - a. Rate for service pressure of 125 psig at 250 degrees F.
 - b. Size for 1 psig maximum pressure drop at design flow rate.
- C. Electronic Operators:
 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.
- D. Radiation Valves:
 1. Bronze body, bronze trim, 2 or 3 port as indicated, replaceable plugs and seats, union and threaded ends.
 2. Rate for service pressure of 125 psig at 250 degrees F.
 3. Size for 3 psig maximum pressure drop at design flow rate.
 4. two-way valves shall have equal percentage characteristics, three way valves linear characteristics. Size two-way valve operators to close valves against pump shut off head.
 5. Operators (2 Position): Synchronous motor with enclosed gear train, dual return springs, valve position indicator; 24 v DC, 0.4 amp. Valves shall spring return to normal position for temperature protection.
 6. Operators (Modulating): Self-contained, linear motorized actuator with approximately 3/4 inch stroke, 60 second full travel with transformer and SPDT contacts: 24 v DC, 6 watt maximum input.

2.04 DAMPERS

- A. Performance: Test in accordance with AMCA 500-D.
- B. Frames: Galvanized steel, welded or riveted with corner reinforcement, minimum 12 gage, 0.1046 inch.
- C. Blades: Galvanized steel, maximum blade size 8 inches wide, 48 inches long, minimum 22 gage, 0.0299 inch, attached to minimum 1/2 inch shafts with set screws.
- D. Blade Seals: Synthetic elastomeric, inflatable, mechanically attached, field replaceable.
- E. Jamb Seals: Spring stainless steel.
- F. Shaft Bearings: Oil impregnated sintered bronze.
- G. Linkage Bearings: Oil impregnated sintered bronze.
- H. Leakage: Less than one percent based on approach velocity of 2000 ft per min and 4 inches wg.
- I. Maximum Pressure Differential: 6 inches wg.
- J. Temperature Limits: Minus 40 to 200 degrees F.

2.05 DAMPER OPERATORS

- A. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
 1. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.
 2. Provide one operator for maximum 36 sq ft damper section.
- B. Electric Operators:
 1. Spring return, adjustable stroke motor having oil immersed gear train, with auxiliary end switch.

2.06 HUMIDISTATS

- A. Room Humidistats:
 1. Wall mounted, proportioning type.

2. Throttling Range: Adjustable 2 percent relative humidity.
 3. Operating Range: 30 to 80 percent.
 4. Maximum Temperature: 110 degrees F.
 5. Cover: Set point indication.
- B. Limit Duct Humidistats:
1. Insertion, two position type.
 2. Throttling Range: Adjustable 2 percent relative humidity.
 3. Operating Range: 20 to 80 percent.
 4. Maximum Temperature: 150 degrees F.

2.07 INPUT/OUTPUT SENSORS

- A. Temperature Sensors:
1. Use thermistor or RTD type temperature sensing elements with characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy.
 2. Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F.
 3. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
 4. Temperature Sensing Device: Compatible with project DDC controllers.
 5. Performance Characteristics:
 - a. RTD:
 - 1) Room Sensor Accuracy: Plus/minus 0.50 degrees F minimum.
 - 2) Duct Averaging Accuracy: Plus/minus 0.50 degrees F minimum.
 - 3) Chilled Water Accuracy: Plus/minus 0.50 degrees F minimum.
 - 4) All Other Accuracy: Plus/minus 0.75 degrees F minimum.
 - 5) Range: Minus 40 degrees F through 220 degrees F minimum.
 - b. Thermistor:
 - 1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
 - 2) Range: Minus 25 degrees F through 122 degrees F minimum.
 - 3) Heat Dissipation Constant: 2.7 mW per degree C.
 - c. Temperature Transmitter:
 - 1) Accuracy: 0.10 degree F minimum or plus/minus 0.20 percent of span.
 - 2) Output: 4 to 20 mA.
 - d. Sensing Range:
 - 1) Provide limited range sensors if required to sense the range expected for a respective point.
 - 2) Use RTD type sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
 - 3) Use temperature transmitters in conjunction with RTD's when RTD's are incompatible with DDC controller direct temperature input.
 - e. Wire Resistance:
 - 1) Use appropriate wire size to limit temperature offset due to wire resistance to 1.0 degree F or use temperature transmitter when offset is greater than 1.0 degree F due to wire resistance.
 - 2) Compensate for wire resistance in software input definition when feature is available in the DDC controller.
 - f. Room Sensors: Locking cover.
 - g. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
 - h. Immersion Temperature Sensors: A sensor encased in a corrosion-resistant probe with an indoor junction box service entry body.
 - i. Ceiling and Recessed Mount Temperature Sensors: Ceiling-mounted sensor in a low-profile housing.
 - j. Room Security Sensors: Stainless steel cover plate with insulated back and security screws.
 - k. 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.
- l. Room Temperature Sensors with Integral Digital Display:
 - 1) Construct for surface or wall box.
 - 2) Provide a four button keypad with the following capabilities:
 - (a) Indication of space temperatures.
 - (b) Setpoint adjustment to accommodate room setpoint and DDC Input/Output Points List.
 - (c) Manual occupancy override and indication of occupancy status.
 - (d) Controller mode status.
- m. Temperature Averaging Elements:
 - 1) Use on duct sensors for ductwork 10 sq ft or larger.
 - 2) Use averaging elements where prone to stratification with sensor length 8 ft or 16 ft.
 - 3) Provide for all mixed air and heating coil discharge sensors regardless of duct size.
- n. Insertion Elements:
 - 1) Use in ducts not affected by temperature stratification or smaller than 11 sq inches.
 - 2) Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches.
- B. Humidity Sensors:
 - 1. Duct Mounted Sensor: Voltage type encased in a die-cast metal, weather-proof housing.
 - a. Input Power, Voltage Type: Class 2; 12-30 VDC/24 VAC, 15mA max.
 - b. Input Power, mA Type: Class 2; Loop powered 12-30 VDC only, 30 mA max.
 - c. Output Voltage Type: 3-wire observed polarity.
 - d. Output mA Type: 2-wire, not polarity sensitive (clipped and capped).
 - e. Humidity:
 - 1) HS Element: Digitally profiled thin-film capacitive.
 - 2) Accuracy 1 percent at 10 to 80 percent relative humidity at 77 degrees F, multi-point calibration, NIST traceable.
 - (a) Plus/minus 1 percent at 20 to 40 percent RH in mA output mode; (multi-point calibration, NIST traceable).
 - 3) Scaling: 0 to 100 percent RH.
 - f. Temperature Effect:
 - 1) Duct Mounted: Plus/minus 0.18 percent per degree F.
 - 2) Outdoor Mounted: 4 to 20mA version: $(0.0013 \times \%RH \times (T_{\text{degreeC}} - 25))$.
 - g. Hysteresis: 1.5 percent typical.
 - h. Linearity: Included in accuracy specification.
 - i. Reset Rate: 24 hours.
 - j. Stability: Plus/minus 1 percent at 68 degrees F (20 degrees C) annually, for two years.
 - k. Temperature Monitoring:
 - 1) Temperature Transmitter Output: Digital, 4 to 20mA (clipped and capped) or 0-5V/0-10V output.
 - (a) HO Transmitter Accuracy: Plus/minus 2.3 degrees F.
 - (b) HD Transmitter Accuracy: Plus/minus 1.0 degree F.
 - l. Operating Environment:
 - 1) Operating Humidity Range: 0 to 100 percent RH noncondensing.
 - 2) Operating Temperature Range: Minus 40 degrees F to 122 degrees F.
 - 2. Wall Mounted Sensor: Voltage type encased in a plastic housing.

- C. Static Pressure (Air Pressure) Sensors:
 - 1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
 - 2. Temperature compensate with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F.
 - 3. Accuracy: One percent of full scale with repeatability 0.3 percent.
 - 4. Output: 0 to 5 vdc with power at 12 to 28 vdc.
- D. Equipment Operation (Current) Sensors:
 - 1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg.
 - 2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi.
 - 3. Status Inputs for Electric Motors: Current sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
- E. Damper Position Indicators: Potentiometer mounted in enclosure with adjustable crank arm assembly connected to damper to transmit 0 to 100 percent damper travel.
- F. Carbon Monoxide Sensors, for Single-Gang Electrical Box Mounting:
 - 1. General:
 - a. Provide gas platform, wired to the building controller, with replaceable sensor.
 - b. Input Power: Class 2; 15 to 30 VDC/24 VAC plus/minus 20 percent, 50/60 Hz.
 - c. Relay Ratings: 1A/30VAC/DC, normally open.
 - d. Operating Temperature Range: Minus 4 degrees F to 122 degrees F.
 - e. Operating Humidity Range: 0 to 90 percent RH non-condensing.
 - f. Terminal Block Wire Size: 30 AWG (0.255 mm) by 12 AWG (2.05 mm).
 - g. Terminal Block Torque: 0.37 to 0.44 inch-lbf.
 - h. Protection Class: IP20 in accordance with IEC 60529.
 - 2. Sensor:
 - a. Sensor Type: Electrochemical.
 - b. Measurement Range: 0 to 200 ppm.
 - c. Accuracy: Plus/minus 5 percent of range.
 - d. Resolution: 1 ppm.
 - e. Sensor Warranty: 2 years from manufacture date.
 - f. Low Setpoint Value: 25 ppm or 50 ppm switch selectable.
 - g. High Setpoint Value: 180 ppm (fixed).
 - h. Operating Temperature Range: Minus 4 degrees F to 122 degrees F.
 - i. Operating Humidity Range: 0 to 90 percent RH non-condensing.
- G. Carbon Dioxide Sensors, Duct and Wall:
 - 1. General: Provide non-dispersive infrared (NDIR), diffusion sampling CO2 sensors with integral transducers and linear output.
 - 2. Air Temperature: Range of 32 to 122 degrees F.
 - 3. Relative Humidity: Range of 0 to 95 percent (non-condensing).
 - 4. Power Input: Class 2; 12 to 30VDC or 24VAC 50/60 Hz; 100mA max.
 - 5. Calibration Characteristics:
 - a. Automatically compensating algorithm for sensor drift due to sensor degradation.
 - b. Maximum Drift: 2 percent.
 - c. User calibratable with a minimum calibration interval of 5 years.
 - 6. Construction:
 - a. Sensor Chamber: Non-corrosive material for neutral effect on carbon dioxide sample.
 - b. Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.
 - c. Housing: High impact plastic.
 - 7. Optional Equipment
 - a. Temperature Sensor:

- 1) Solid state, integrated circuit; Accuracy: Plus/minus 1 degree F; Resolution: 0.2 degrees F; Output Range: 50 to 95 degrees F.

2.08 THERMOSTATS

- A. Electric Room Thermostats:
 1. Type: NEMA DC 3, 24 volts, with setback/setup temperature control.
 2. Service: Cooling and heating.
 3. Covers: Locking with set point adjustment, with thermometer.
- B. Line Voltage Thermostats:
 1. Integral manual On/Off/Auto selector switch, single or two pole as required.
 2. Dead Band: Maximum 2 degrees F.
 3. Cover: Locking with set point adjustment, with thermometer.
 4. Rating: Motor load.
- C. Room Thermostat Accessories:
 1. Thermostat Covers: Brushed aluminum.
 2. Insulating Bases: For thermostats located on exterior walls.
 3. Thermostat Guards: Metal mounted on separate base.
 4. Adjusting Key: As required for device.
 5. Aspirating Boxes: Where indicated for thermostats requiring flush installation.
- D. Outdoor Reset Thermostats:
 1. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.
 2. Scale range: Minus 10 to 70 degrees F.
- E. Immersion Thermostats:
 1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint and adjustable throttling range.
- F. Airstream Thermostats:
 1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint in middle of range and adjustable throttling range.
 2. Averaging service remote bulb element: 7.5 feet.
- G. Electric Low Limit Duct Thermostats:
 1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint,
 2. Bulb length: Minimum 20 feet.
 3. Provide one thermostat for every 20 sq ft of coil surface.
- H. Electric High Limit Duct Thermostats:
 1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or above setpoint,
 2. Bulb length: Minimum 20 feet.
 3. Provide one thermostat for every 20 sq ft of coil surface.
- I. Fire Thermostats:
 1. UL labeled, factory set in accordance with NFPA 90A.
 2. Normally closed contacts, manual reset.
- J. Heating/Cooling Valve Top Thermostats:
 1. Proportional acting for proportional flow, molded rubber diaphragm, remote bulb liquid filled element, direct and reverse acting at differential pressure to 25 psig, cast housing with position indicator and adjusting knob.

2.09 TRANSMITTERS

- A. Building Static Pressure Transmitters:
 1. One pipe, direct acting, double bell, scale range 0.01 to 6.0 inch wg positive or negative, and sensitivity of 0.0005 inch wg. Transmit electronic signal to receiver with matching scale range.

- B. Pressure Transmitters:
 - 1. One pipe direct acting indicating type for gas, liquid, or steam service, range suitable for system, proportional electronic output.
- C. Air Pressure Transmitters:
 - 1. General: Provide dry media differential pressure transducers to monitor duct and room pressure.
 - a. Media Compatibility: Dry air.
 - b. Input Power: Class 2; 12 to 30 VDC; 2-wire: 20 mA max.
 - c. Output: Field selectable, 2-wire, loop-powered 4 to 20 mA (DC only, clipped and capped).
 - d. Response Time:
 - 1) Standard: T95 in 20 seconds.
 - 2) Fast: T95 in 2 seconds.
 - 3) Switch selectable.
 - e. Mode: Switch selectable, unidirectional.
 - f. Display:
 - 1) Signed 3-1/2 digit LCD, indicates pressure.
 - 2) Over-range indicator.
 - g. Proof Pressure (pressure differential): 3 psid.
 - h. Burst Pressure (pressure differential): 5 psid.
 - i. Accuracy: Plus/minus 1 percent f.s. (full scale) of selected range (combined linearity & hysteresis).
 - j. Temperature Effect (per transmitter size):
 - 1) 1 inch w.c.: 2.0 percent per degree C.
 - 2) 10 inch w.c.: 0.01 percent per degree C.; (Relative to 25 degrees C) 32 degrees F to 122 degrees F.
 - k. Zero Drift (1-year) (per transmitter size):
 - 1) 1 inch w.c.: 2 percent maximum.
 - 2) 10 inch: 0.05 percent maximum.
 - l. Zero adjust: Pushbutton auto-zero and digital input (2-pos terminal block).
 - m. Operating Environment:
 - 1) 32 degrees F to 140 degrees F.
 - 2) 0 to 90 percent RH noncondensing.
 - n. Fittings:
 - 1) Brass barb.
 - 2) 0.24 inches outer diameter.
 - 3) UL 94 V-O fire retardant ABS.
- D. Water Pressure Transmitters (Liquid Differential Pressure Transmitters):
 - 1. General: Provide wet media differential pressure transducers with 6 ft (1.83 m) armored cable, to allow remote pressure sensing capability using existing plumbing runs.
 - a. Input Power: Class 2; 15 to 30 VDC, 24VAC nominal, 50/60 Hz.
 - b. Maximum Current Draw:
 - 1) DC: 125 mA.
 - 2) AC: 280 mA.
 - c. Output: 3-wire transmitter; user-selectable, 4 to 20 mA (0 to 5V/0 to 10V).
 - d. 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 for less than or equal 20 ft:
 - (a) Ranges A and B: Plus/minus 1 percent F.S. typical.
 - (b) Range C: Plus/minus 1.5 percent F.S. typical.

- (c) Range D: Plus/minus 2 percent F.S. typical.
 - 6) Surge Damping: Electronic; 1 second averaging.
 - 7) Long Term Stability: Plus/minus 0.25 percent.
 - 8) Zero Offset (Bidirectional and Port Swap Modes Only): 0.5 percent.
 - e. Reverser:
 - 1) Zero Adjust: Push button auto-zero and digital input (2-position terminal block).
 - 2) Fittings:
 - (a) 27 NPT female thread, stainless steel 17 to 4 PH.
 - f. Pressure Ranges:
 - 1) 0 psi to 50 psi (Gauge): 5 psid/10 psid/25 psid/50 psid (pressure differential).
 - 2) 0 psi to 100 psi (Gauge): 10 psid/20 psid/50 psid/100 psid (pressure differential).
 - 3) 0 psi to 250 psi (Gauge): 25 psid/50 psid/125 psid/250 psid (pressure differential).
 - g. Operating Conditions:
 - 1) Temperature Compensated Range:
 - (a) 32 degrees F.
 - (b) TC Zero less than 1.5 percent of product F.S. (full scale) per sensor.
 - (c) TC Span less than 1.5 percent of product F.S. (full scale) per sensor.
 - 2) Sensor Operating Range: Minus 4 degrees F to 185 degrees F.
 - 3) Operating Environment: 14 degrees F to 122 degrees F; 10 to 90 percent RH noncondensing.
 - h. Enclosure: NEMA 250, Type 4.
- E. Temperature Transmitters:
- 1. One pipe, directly proportional output signal to measured variable, linearity within plus or minus 1/2 percent of range for 200 degrees F span and plus or minus 1 percent for 50 degrees F span, with 50 degrees F. temperature range, compensated bulb, averaging capillary, or rod and tube operation on 20 psig input pressure and 3 to 15 psig output.
- F. Humidity Transmitters:
- 1. One pipe, directly proportioned output signal to measured variable, linearity within plus or minus 1 percent for 70 percent relative humidity span, capable of withstanding 95 percent relative humidity without loss of calibration.

2.10 FLOW SENSORS

- A. Venturi Tubes:
- 1. Fabricate the venturi tube from cast iron with an accuracy of plus/minus 1 percent of full flow.
 - 2. Line the throat section with austenitic stainless steel.
 - 3. Thermal Expansion Characteristics of the Lining: Same as that of the throat casting material.
 - 4. Machine the surface of the throat to plus/minus 50 micro-inches including the short curvature leading from the converging entrance section into the throat.
- B. Airflow Measurement Array (AFMA):
- 1. Airflow Straighteners:
 - a. Provide AFMA's with an airflow straightener if required by the AFMA manufacturer's published installation instructions.
 - b. In the absence of published documentation, provide airflow straighteners if there is any duct obstruction within 5 duct diameters upstream of the AFMA.
 - c. Straightener: Contained inside a flanged sheet metal casing, with the AFMA located as specified according to the published recommendations of the AFMA manufacturer.
 - d. Construction to consist of 0.125 inch aluminum honeycomb with the straightener depth not less than 1.5 inches.
 - 2. Outdoor Air Temperature: In outside air measurement or in low-temperature air delivery applications, provide an AFMA certified by the manufacturer to be accurate as specified over a temperature range of minus 20 degrees F to 120 degrees F.

3. Airflow Resistance:
 - a. Resistance to Airflow Through the AFMA and the Airflow Straightener: Not to exceed 0.085 inches at an airflow velocity of 2000 fpm.
 - b. AFMA Construction: Suitable for operation at air flows of up to 5000 fpm over a temperature range of 40 degrees F to 120 degrees F.
4. Electronic:
 - a. Each electronic AFMA to consist of an array of velocity sensing elements of the resistance temperature detector (RTD) or thermistor type.
 - b. Sensing Elements: Distributed across the duct cross section in the quantity and pattern specified or recommended by the published application data of the manufacturer.
 - c. Electronic AFMA's: Accuracy of plus/minus 5 percent over a range of 125 fpm to 5,000 fpm and temperature compensated output over a range of 32 degrees F to 212 degrees F.
- C. Annular Pitot Tubes:
 1. Fabricate the annular pitot tube from austenitic stainless steel with an accuracy of plus/minus 2 percent of full flow and a repeatability of plus/minus 0.50 percent of measured value.
 2. Unit to have at least one static port with no less than four total head pressure ports with an averaging manifold.
- D. Orifice Plates:
 1. Fabricate orifice plate of austenitic stainless steel sheet of 0.125 inches nominal thickness with an accuracy of plus/minus 1 percent of full flow.
 2. Configuration: Flat plate within 0.002 inches.
 3. Orifice Surface Roughness: Not-to-exceed 20 micro-inches.
 4. Orifice Cylindrical Face Thickness: Not-to-exceed 2 percent of the pipe inside diameter or 12.5 percent of the orifice diameter, whichever is smaller.
 5. Upstream Edge of the Orifice Plate: Utilize in all applications except steam flow measurement in horizontal pipelines.
- E. Ultrasonic Flow Meters:
 1. Provide ultrasonic flow meters complete with matched transducers, self aligning installation hardware, and transducer cables.
 2. Optimize ultrasonic transducers for the specific pipe and process conditions for the application.
 3. Flow Meter Accuracy: Plus/minus 1 percent of rate from 0.98 fps to 40 fps.
 4. Include dry contact outputs, 4 to 20 mA, 0 to 10 VDC.
- F. Vortex Shedding Flow Meters:
 1. Accuracy: Within plus/minus 0.8 percent of the actual reading over the range of the meter.
 2. Mass flow inferred from specified steam pressure will not be acceptable.
 3. Fabricate body from austenitic stainless steel and include a NEMA 250, weather tight Type 4X electronics enclosure.
 4. Design of the flowmeter body to not require removal from the piping in order to replace the shedding sensor.
- G. Gas Flow Meters:
 1. Furnish diaphragm or bellows type, gas positive displacement meters, for flows up to 2500 Std cu ft per hour, designed specifically for natural gas supply metering, and rated for the temperature, pressure, and flow rates of the installation.
 2. Minimum Turndown Ratio: 10 to 1 with an accuracy of plus/minus 1 of actual flow rate.
 3. Provide meter index with direct reading mechanical totalizing register and impulse dry contact output for remote monitoring.
 4. Electrical Impulse Dry Contact:
 - a. Field adjustment or calibration not required.

- b. Output: Minimum resolution of 100 cu ft of gas per pulse not to exceed 15 pulses per sec at the design flow.
- H. 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.
 - 4. Furnish non-flexible paddle with magnetically actuated contacts, rated for service at a pressure greater than the installed conditions.
 - 5. Flow Switch for Use in Sewage Systems: Rated for use in corrosive environments encountered.

2.11 LEVEL INSTRUMENTS

- A. Submersible Level Transmitters (Liquids Other Than Potable Water):
 - 1. Provide for aluminum tanks, chemical storage tanks, oil tanks, wastewater, sludge pits, clarifiers, digesters, lime slurry, sumps, and reservoirs.
 - 2. Function: Measurement of the height of liquid above the position in the tank referenced to atmospheric pressure.
 - 3. Material: Piezoresistive sensing element, encased in a 316 stainless steel housing.
 - 4. Large diameter 316 stainless steel diaphragm seal, non-clogging and damage resistant to floating solids.
 - 5. UL approved intrinsically safe for use in hazardous locations when used with proper barrier.
 - 6. Equip with a minimum 270 lb tensile strength, shielded and vented cable.
 - 7. Ventilation tube in cable automatically compensates for changes in atmospheric pressure above the tank.
 - 8. Vent protected with maintenance-free filter eliminating particulate or water droplets from entering transducer.
 - 9. Service: Compatible liquids.
 - 10. Wetted Materials:
 - a. 316 stainless steel.
 - b. Epoxy.
 - c. Cable: ETFE or Polyurethane.
 - 11. Accuracy: Plus/minus 0.25 percent, includes linearity, hysteresis, and repeatability.
 - 12. Temperature Limit: 0 to 200 degrees F.
 - 13. Compensated Temperature Range: 0 to 180 degrees F.
 - 14. Thermal Effect: Plus/minus 0.02 percent per degree F.
 - 15. Pressure Limit: 2X FS.
 - 16. Power Requirement: 13 to 30 VDC.
 - 17. Output Signal: 4 to 20 mA DC, two wire.
 - 18. Response Time: 50 msec or less.
 - 19. Max Loop Resistance: 900 ohms.
 - 20. Electrical Connection: Wire pigtail.
 - 21. Mounting Orientation: Suspended in tank below level being measured.
 - 22. Electrical Protection: Lightning and surge protection.
 - 23. Weight: 4.3 lb.
- B. Flush Tip Submersible Level Transmitters:
 - 1. Provide for industrial slurries, industrial sumps, reservoirs, sewage lift stations, landfill leachate, oil tanks, and sludge pits.
 - 2. Function: Measurement of the height of liquid above the position that it is mounted in a tank or pit in reference to atmospheric pressure.
 - 3. Factory designed with a flush diaphragm tip that will not clog in harsh applications such as sewage lift stations.
 - 4. Narrow body design allows transmitter to fit into stilling wells and narrow installations.
 - 5. Fluoroelastomer Diaphragm:

- a. PTFE coated for stick resistant surface to hold up in aggressive fluids.
 - b. Diaphragm Cavity: Filled with leak proof gel.
 6. Body: 316 SS.
 7. Cable: Polyurethane or ETFE.
 8. Ventilation tube in cable automatically compensates for changes in atmospheric pressure above the fluid.
 9. Vent protected with maintenance free filter eliminating particulate or water droplets from entering the transmitter.
 10. Provide desiccant filter, for extra protection against humidity, that can be attached to the vent tube.
 11. Incorporate lightning and surge protection to stand up in harsh applications.
 12. NPT connection allows the unit to be rigidly installed in a pipe/conduit, or to attach a factory supplied hanging loop for attaching a chain for pulling out of the installation.
 13. Service: Compatible liquids.
 14. Wetted Materials:
 - a. Body: 316 stainless steel.
 - b. Cable: ETFE or Polyurethane.
 - c. Diaphragm: PTFE coated FKM fluoroelastomer.
 - d. Label: Polyethylene polyamide.
 15. Accuracy: Plus/minus 0.25 percent FS 10 inches (25.4 cm) w.c. range is plus/minus 0.30 percent FS.
 16. Temperature Limit: Minus 4 to 176 degrees F.
 17. Compensated Temperature Range: 32 to 140 degrees F.
 18. Thermal Effect: Plus/minus 0.0075 percent per degree F.
 19. Pressure Limit: 2X range.
 20. Power Requirement: 10 to 33 VDC.
 21. Output Signal: 4 to 20 mA DC, two wire.
 22. Response Time: 50 msec or less.
 23. Max Loop Resistance: 1000 ohms at 30 VDC.
 24. Connections:
 - a. Electrical: Wire pigtail.
 - b. Mounting: Suspend below point being monitored.
 25. Electrical Protection: Lightning and surge protection.
 26. Weight:
 - a. Body: 0.3 lb.
 - b. Cable: 0.037 lb per ft.
- C. Submersible Level Transmitters (Potable Water):
1. Provide for well monitoring, ground water monitoring, environmental remediation, surface water monitoring, down hole, and water tanks.
 2. Function: Measurement of the height of liquid above the position in the tank referenced to atmospheric pressure.
 3. Material: Piezoresistive sensing element, encased in a 316 stainless steel housing.
 4. Bullet nose design for protecting diaphragm from damage.
 5. UL approved intrinsically safe for use in hazardous locations when used with proper barrier.
 6. Equip with a 270 lb tensile strength, shielded and vented cable.
 7. Ventilation tube in cable automatically compensates for changes in atmospheric pressure above the tank.
 8. Vent protected with maintenance-free filter eliminating particulate or water droplets from entering transducer.
 9. Service: Compatible liquids.
 10. Wetted Materials:
 - a. 316 stainless steel.
 - b. Epoxy.

- c. Cable: ETFE or Polyurethane.
- d. Bullet Nose: PVC.
- 11. Accuracy: Plus/minus 0.25 percent.
- 12. Temperature Limit: 0 to 150 degrees F.
- 13. Compensated Temperature Range: 0 to 140 degrees F.
- 14. Thermal Effect: Plus/minus 0.02 percent full scale per degree F.
- 15. Pressure Limit: 2X FS.
- 16. Power Requirement: 13 to 30 VDC.
- 17. Output Signal: 4 to 20 mA DC, two wire.
- 18. Response Time: 50 msec or less.
- 19. Max Loop Resistance: 900 ohms at 30 VDC.
- 20. Electrical Connection: Wire pigtail.
- 21. Mounting Orientation: Suspended in tank below level being measured.
- 22. Electrical Protection: Lightning and surge protection.
- 23. Weight: 2.2 lb.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Check and verify location of thermostats with plans and room details before installation. Locate 60 inches above floor. Align with lighting switches and humidistats. Refer to Section 26 27 26.
- C. Mount freeze protection thermostats using flanges and element holders.
- D. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
- E. Provide separable sockets for liquids and flanges for air bulb elements.
- F. Provide thermostats in aspirating boxes in front entrances.
- G. Provide guards on thermostats in entrances and public areas.
- H. Provide valves with position indicators and with pilot positioners where sequenced with other controls.
- I. Provide separate steam valves for each bank of coils. Provide two valves in parallel where steam load exceeds 1500 lb per hr with 1/3 to 2/3 load capacities sequenced with smaller valve opening first.
- J. Provide mixing dampers of opposed blade construction arranged to mix streams. Provide pilot positioners on mixed air damper motors.
- K. Provide isolation (two position) dampers of parallel blade construction.
- L. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
- M. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside

cabinet and engraved plastic nameplates on cabinet face.

- N. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- O. Provide conduit and electrical wiring. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

3.03 MAINTENANCE

- A. Provide service and maintenance of control system for one year from Date of Substantial Completion.
- B. Provide complete service of controls systems, including call backs, and submit written report of each service call.
- C. In addition to normal service calls, make minimum of 2 complete normal inspections of approximately 4 hours duration to inspect, calibrate, and adjust controls.

3.04 SCHEDULES

- A. Control Valve Schedule
 - 1. Drawing Code
 - 2. Valve Size
 - 3. Valve CV
 - 4. Operator Spring Range
 - 5. Normal Position
- B. Control Damper Schedule
 - 1. Drawing Code
 - 2. Height
 - 3. Width
 - 4. Air Flow
 - 5. Air Pressure Drop

END OF SECTION

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SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 REFERENCE STANDARDS

- A. ASHRAE Std 135 - A Data Communication Protocol for Building Automation and Control Networks 2020, with Errata and Amendments (2022).
- B. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests 2019h.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 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.

1.04 SUBMITTALS

- A. Product Data: Provide data for each system component and software module.
- B. Shop Drawings:
 - 1. Indicate trunk cable schematic showing programmable control unit locations, and trunk data conductors.
 - 2. List connected data points, including connected control unit and input device.
 - 3. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration digital media containing graphics.
 - 4. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
 - 5. Indicate description and sequence of operation of operating, user, and application software.
- C. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.
 - 1. Revise shop drawings to reflect actual installation and operating sequences.
 - 2. Include submittals data in final "Record Documents" form.
- D. Operation and Maintenance Data:
 - 1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
 - 2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
 - 3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
- E. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

- A. Perform work in accordance with NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years of documented experience.

1.06 WARRANTY

- A. Correct defective Work within a five year period after Substantial Completion.
- B. Provide five year manufacturer's warranty for field programmable micro-processor based units.

1.07 PROTECTION OF SOFTWARE RIGHTS

- A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
 - 1. Limiting use of software to equipment provided under these specifications.
 - 2. Limiting copying.
 - 3. Preserving confidentiality.
 - 4. Prohibiting transfer to a third party.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Johnson Controls, Inc.
- B. Siemens AG, Building Technologies Division

2.02 SYSTEM DESCRIPTION

- A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units.
- B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
- C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.
- D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 23 09 13.
- 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.

2.03 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. Desktop:
 - a. Computer and display to be provided by DDC controls manufacturer.
 - b. Quantity: (1).
 - c. Location(s): As indicated on the Drawings.
 - d. Network Connection:
 - 1) Ethernet interface card.

2.04 CONTROLLERS

- A. BUILDING CONTROLLERS

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

B. CUSTOM APPLICATION CONTROLLERS

1. General:
 - a. Provide sufficient memory to support controller's operating system, database, and programming requirements.
 - b. Share data between networked, microprocessor based controllers.
 - c. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
 - d. Utilize real-time clock for scheduling.
 - e. Continuously check processor status and memory circuits for abnormal operation.
 - f. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
 - g. Communication with other network devices to be based on assigned protocol.
2. Communication:
 - a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.

- b. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
- 3. Anticipated Environmental Ambient Conditions:
 - a. Outdoors and/or in Wet Ambient Conditions:
 - 1) Mount within waterproof enclosures.
 - 2) Rated for operation at 40 to 150 degrees F.
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.
- 4. Provisions for Serviceability:
 - a. Diagnostic LED's for power, communication, and processor.
 - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
- 5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
- 6. Power and Noise Immunity:
 - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
 - b. Perform orderly shutdown below 80 percent of nominal voltage.
 - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

C. APPLICATION SPECIFIC CONTROLLERS

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

D. INPUT/OUTPUT INTERFACE

- 1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.
- 2. All Input/Output Points:

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

2.05 POWER SUPPLIES AND LINE FILTERING

- A. Power Supplies:
 1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
 2. Limit connected loads to 80 percent of rated capacity.
 3. Match DC power supply to current output and voltage requirements.
 4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
 5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
 6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
 7. Operational Ambient Conditions: 32 to 120 degrees F.

8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
 9. Line voltage units UL recognized and CSA approved.
- B. Power Line Filtering:
1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
 2. Minimum surge protection attributes:
 - a. Dielectric strength of 1000 volts minimum.
 - b. Response time of 10 nanoseconds or less.
 - c. Transverse mode noise attenuation of 65 dB or greater.
 - d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

2.06 SYSTEM SOFTWARE

- A. Operating System:
1. Concurrent, multi-tasking capability.
 - a. Common Software Applications Supported: Microsoft Excel.
 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.
 - 6) Unit Ventilators.
 - b. Ancillary Equipment:
 - 1) Fans.
 - 2) Pumps.
 - 3) Coils.
 - 4) Valves.
 - 5) Piping.
 - 6) Dampers.
 - 7) Ductwork.
- B. Workstation System Applications:
1. Automatic System Database Save and Restore Functions:
 - a. Current database copy of each Building Controller is automatically stored on hard disk.
 - b. Automatic update occurs upon change in any system panel.

- c. In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.
2. Manual System Database Save and Restore Functions by Operator with Password Clearance:
 - a. Save database from any system panel.
 - b. Clear a panel database.
 - c. Initiate a download of a specified database to any system panel.
3. Software provided allows system configuration and future changes or additions by operators under proper password protection.
4. On-line Help:
 - a. Context-sensitive system assists operator in operation and editing.
 - b. Available for all applications.
 - c. Relevant screen data provided for particular screen display.
 - d. Additional help available via hypertext.
5. Security:
 - a. Operator log-on requires user name and password to view, edit, add, or delete data.
 - b. System security selectable for each operator.
 - c. System supervisor sets passwords and security levels for all other operators.
 - d. Operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
 - e. Automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
 - f. All system security data stored in encrypted format.
6. System Diagnostics:
 - a. Operations Automatically Monitored:
 - 1) Workstations.
 - 2) Printers.
 - 3) Modems.
 - 4) Network connections.
 - 5) Building management panels.
 - 6) Controllers.
 - b. Device failure is annunciated to the operator.
7. Alarm Processing:
 - a. All system objects are configurable to "alarm in" and "alarm out" of normal state.
 - b. Configurable Objects:
 - 1) Alarm limits.
 - 2) Alarm limit differentials.
 - 3) States.
 - 4) Reactions for each object.
8. Alarm Messages:
 - a. Descriptor: English language.
 - b. Recognizable Features:
 - 1) Source.
 - 2) Location.
 - 3) Nature.
9. Configurable Alarm Reactions by Workstation and Time of Day:
 - a. Logging.
 - b. Printing.
 - c. Starting programs.
 - d. Displaying messages.
 - e. Dialing out to remote locations.
 - f. Paging.
 - g. Providing audible annunciation.

- h. Displaying specific system graphics.
- 10. Custom Trend Logs:
 - a. Definable for any data object in the system including interval, start time, and stop time.
 - b. Trend Data:
 - 1) Sampled and stored on the building controller panel.
 - 2) Archivable on hard disk.
 - 3) Retrievable for use in reports, spreadsheets and standard database programs.
 - 4) Archival on LAN accessible storage media including hard disk, tape, Raid array drive, and virtual cloud environment.
 - 5) Protected and encrypted format to prevent manipulation, or editing of historical data and event logs.
- 11. Alarm and Event Log:
 - a. View all system alarms and change of states from any system location.
 - b. Events listed chronologically.
 - c. Operator with proper security acknowledges and clears alarms.
 - d. Alarms not cleared by operator are archived to the workstation hard disk.
- 12. Object, Property Status and Control:
 - a. Provide a method to view, edit if applicable, the status of any object and property in the system.
 - b. Status Available by the Following Methods:
 - 1) Menu.
 - 2) Graphics.
 - 3) Custom Programs.
- 13. Reports and Logs:
 - a. Reporting Package:
 - 1) Allows operator to select, modify, or create reports.
 - 2) Definable as to data content, format, interval, and date.
 - 3) Archivable to hard disk.
 - b. Real-time logs available by type or status such as alarm, lockout, normal, etc.
 - c. Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
 - d. Set to be printed on operator command or specific time(s).
- 14. Reports:
 - a. Standard:
 - 1) Objects with current values.
 - 2) Current alarms not locked out.
 - 3) Disabled and overridden objects, points and SNVTs.
 - 4) Objects in manual or automatic alarm lockout.
 - 5) Objects in alarm lockout currently in alarm.
 - 6) Logs:
 - (a) Alarm History.
 - (b) System messages.
 - (c) System events.
 - (d) Trends.
 - b. Custom:
 - 1) Daily.
 - 2) Weekly.
 - 3) Monthly.
 - 4) Annual.
 - 5) Time and date stamped.
 - 6) Title.
 - 7) Facility name.
 - c. Tenant Override:

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

2.07 CONTROLLER SOFTWARE

- A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.
- B. System Security:
 - 1. User access secured via user passwords and user names.
 - 2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
 - 3. User Log On/Log Off attempts are recorded.
 - 4. Automatic Log Off occurs following the last keystroke after a user defined delay time.
- C. Object or Object Group Scheduling:
 - 1. Weekly Schedules Based on Separate, Daily Schedules:
 - a. Include start, stop, optimal stop, and night economizer.
 - b. 10 events maximum per schedule.
 - c. Start/stop times adjustable for each group object.
 - 2. Exception Schedules:
 - a. Based on any day of the year.
 - b. Defined up to one year in advance.
 - c. Automatically discarded and replaced with standard schedule for that day of the week upon execution.
 - 3. Holiday or Special Schedules:
 - a. Capability to define up to 99 schedules.
 - b. Repeated annually.
 - c. Length of each period is operator defined.
- D. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.
- E. Alarms:
 - 1. Binary object is set to alarm based on the operator specified state.
 - 2. Analog object to have high/low alarm limits.
 - 3. All alarming is capable of being automatically and manually disabled.
 - 4. Alarm Reporting:
 - a. Operator determines action to be taken for alarm event.
 - b. Alarms to be routed to appropriate workstation.
 - c. Reporting Options:
 - 1) Start programs.
 - 2) Logged.
 - 3) Custom messaging.
 - 4) Graphical displays.
- F. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.
- G. 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.
- H. Staggered Start Application:
 - 1. Prevents all controlled equipment from simultaneously restarting after power outage.
 - 2. Order of equipment startup is user selectable.
- I. Energy Calculations:
 - 1. Accumulated instantaneous power or flow rates are converted to energy use data.
 - 2. Algorithm calculates a rolling average and allows window of time to be user specified in minute intervals.
 - 3. Algorithm calculates a fixed window average with a digital input signal from a utility meter defining the start of the window period that in turn synchronizes the fixed-window average

with that used by the power company.

- J. Anti-Short Cycling:
 - 1. All binary output objects protected from short-cycling.
 - 2. Allows minimum on-time and off-time to be selected.
- K. 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.
- L. Run-Time Totalization:
 - 1. Totalize run-times for all binary input objects.
 - 2. Provides operator with capability to assign high run-time alarm.

2.08 HVAC CONTROL PROGRAMS

- A. General:
 - 1. Support Inch-pounds and SI (metric) units of measurement.
 - 2. Identify each HVAC Control system.
- B. Optimal Run Time:
 - 1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
 - 2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
 - 3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
 - 4. Operator commands:
 - a. Define heating/cooling parameters.
 - b. Request optimal run time control summary.
 - c. Request HVAC point summary.
 - 5. Control Summary:
 - a. HVAC Control system begin/end status.
 - b. Optimal run time lock/unlock control status.
 - c. Heating/cooling mode status.
 - d. Optimal run time schedule.
 - e. Start/Stop times.
 - f. Optimal run time system normal start times.
 - g. Occupancy and vacancy times.
 - 6. HVAC point summary:
 - a. Control system identifier and status.
 - b. Point ID and status.
 - c. Outside air temperature point ID and status.
 - d. Calculated optimal start and stop times.
- C. Supply Air Reset:
 - 1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.
 - 2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
 - a. Raising cooling temperatures to highest possible value.
 - b. Reducing heating temperatures to lowest possible level.
 - 3. Operator commands:
 - a. Request HVAC point summary.
 - b. Define discharge controller parameters.
 - c. Request space load summary.
 - 4. Control summary:
 - a. Supply air reset system status.
 - b. Optimal run time system status.

5. Space load summary:
 - a. HVAC system status.
 - b. Optimal run time status.
 - c. Calculated reset values.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
- B. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 23 09 93.
- C. Provide conduit and electrical wiring in accordance with Section 26 05 83. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

3.03 MANUFACTURER'S FIELD SERVICES

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

3.04 DEMONSTRATION AND INSTRUCTIONS

- A. Demonstrate complete and operating system to Owner.

3.05 MAINTENANCE

- A. Provide service and maintenance of energy management and control systems for one years from Date of Substantial Completion.
- B. Provide two complete inspections per year, one in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.
- C. 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

**SECTION 23 09 33
VARIABLE-FREQUENCY DRIVES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Variable frequency controllers.

1.02 REFERENCE STANDARDS

- A. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems 2014.
- B. NEMA ICS 7 - Industrial Control and Systems: Adjustable-Speed Drives 2020.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.
- D. Specification compliance review.
- E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- F. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.
- G. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.

1.04 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.

1.05 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Variable Frequency Motor Controllers:
 - 1. ABB/GE:
 - 2. Danfoss:
 - 3. Schneider Electric; Square D Products:
 - 4. Yaskawa
 - 5. York/Toshiba
 - 6. JCI

- B. Source Limitations: Furnish variable frequency motor controllers and associated components produced by a single manufacturer and obtained from a single supplier.

2.02 DESCRIPTION

- A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in compliance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
 - 1. Employ pulse-width-modulated inverter system.
 - 2. Design for ability to operate controller with motor disconnected from output.
- B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places regularly open to the public.
- C. VFDs shall be provided with interface for Building Automation System (BAS). VFDs shall not be installed on owner IT network.
- D. VFDs motor transfer circuit shall include three contacts for bypass switching from line to VFD and vice versa.
- E. Motors 50 hp and under shall be specified with minimum 6-pulse drives. Motors larger than 50 hp require minimum 18-pulse drives or 6-pulse drives with passive filters.
 - 1. Each VFD over 50 hp shall be provided with a passive harmonic filter or 18-pulse phase shifting transformer to limit the total harmonic current distortion and voltage distortion.
 - 2. Filter transformers shall be compatible with the 6-pulse inverter. All components must be installed in a single contiguous enclosure.
- F. VFDs serving fans and pumps (e.g. AHUs, chilled water, cooling towers) shall have the ability to lock out critical speeds.
- G. To ensure generator compatibility, harmonic filters must never introduce a capacitive reactive power (KVAR), which is greater than 20% of its KVA rating.
- H. Filter/transformer to be disconnected from circuit when operating in bypass mode.
- I. VFDs with active front end units and regenerative VFDs are not allowed.

2.03 OPERATING REQUIREMENTS

- A. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.
 - 1. Total Power Factor shall be >0.98 at loads greater than 50%.
- B. Operating Ambient: 0 degrees C to 40 degrees C.
- C. Minimum Efficiency at Full Load: 96 percent.
- D. Current Limit Adjustment: 60 to 110 percent of rated.
- E. Harmonic Performance: THiD shall be 5% or less at loads greater than 60%. THvD shall be <2% with <5% line voltage imbalance.

2.04 COMPONENTS

- A. Display: Provide integral digital display to indicate output voltage, output frequency, and output current.
- B. Status Indicators: Separate indicators for overcurrent, overvoltage, ground fault, overtemperature, and input power ON.
- C. Furnish HAND-OFF-AUTOMATIC selector switch and manual speed control.
- D. Control Power Source: Integral control transformer.
- E. Door Interlocks: Furnish mechanical means to prevent opening of equipment with power connected, or to disconnect power if door is opened; include means for defeating interlock by qualified persons.
- F. Safety Interlocks: Furnish terminals for remote contact to inhibit starting under both manual and automatic mode.

- G. Disconnecting Means: Include integral fused disconnect switch on the line side of each controller.
- H. Provide shaft ground for motors controlled by VFD.

2.05 SOURCE QUALITY CONTROL

- A. Shop inspect and perform standard productions tests for each controller.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that surface is suitable for controller installation.
- B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.

3.02 INSTALLATION

- A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.
- B. Provide required support and attachment in accordance with Section 26 05 29.
- C. Tighten accessible connections and mechanical fasteners after placing controller.
- D. Provide fuses in fusible switches; refer to Section 26 28 13 for product requirements.

3.03 FIELD QUALITY CONTROL

- A. Provide the service of the manufacturer's field representative to prepare and start controllers.
- B. Perform field inspection and testing in accordance with Section 01 40 00.

3.04 ADJUSTING

- A. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

3.05 CLOSEOUT ACTIVITIES

- A. Demonstrate operation of controllers in automatic and manual modes.

3.06 MAINTENANCE

- A. VFDs shall be provided with a warranty of not less than 36 months from startup.
- B. Provide a separate maintenance contract for specified maintenance service.
- C. Provide service and maintenance of controllers for one year from Date of Substantial Completion.

END OF SECTION

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**SECTION 23 11 23
FACILITY NATURAL-GAS PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe, pipe fittings, valves, and connections for natural gas piping systems.

1.02 RELATED REQUIREMENTS

- A. Section 33 52 16 - Gas Hydrocarbon Piping.

1.03 REFERENCE STANDARDS

- A. ANSI Z21.18/CSA 6.3 - Gas Appliance Pressure Regulators 2019.
- B. ANSI Z21.80/CSA 6.22 - Line Pressure Regulators 2019.
- C. ANSI Z223.1 - National Fuel Gas Code 2021.
- D. ASME BPVC-IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators - Welding Brazing and Fusing Qualifications 2019.
- E. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- F. ASME B31.1 - Power Piping 2022.
- G. ASME B31.9 - Building Services Piping 2020.
- H. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- I. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- J. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2022.
- K. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems 2018.
- L. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements 2015.
- M. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements 2015.
- N. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements 2015.
- O. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).
- P. MSS SP-78 - Gray Iron Plug Valves, Flanged and Threaded Ends 2011.
- Q. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends 2010, with Errata .

1.04 SUBMITTALS

- A. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- B. Shop Drawings: Submit detailed layout developed for this project.
- C. Project Record Documents: Record actual locations of valves.

1.05 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.

PART 2 PRODUCTS

2.01 NATURAL GAS PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.
 - 1. Fittings: ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: ANSI Z223.1, welded.
 - 3. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

2.02 NATURAL GAS PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black steel, Type E or S, Grade B.
 - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: Threaded or welded to ASME B31.1.

2.03 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 Inches and Under:
 - 1. Ferrous pipe: Class 150 malleable iron threaded unions.
- B. Flanges for Pipe Size Over 1 Inch:
 - 1. Ferrous Pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.

2.04 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 - 2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze 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/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
 - e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.
- B. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
 - 1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
 - 2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
 - 3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
 - 4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.

2.05 BALL VALVES

- A. Construction, 4 Inches and Smaller: MSS SP-110, Class 150, 400 psi CWP, bronze or ductile iron body, 304 stainless steel or chrome plated brass ball, regular port, Teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, threaded ends with union.

2.06 PLUG VALVES

- A. Construction 2-1/2 Inches and Larger: MSS SP-78, 175 psi CWP, cast iron body and plug, pressure lubricated, Teflon or Buna N packing, flanged ends. Provide lever operator with set

screw.

2.07 STRAINERS

- A. Size 2 inch and Under:
 - 1. Threaded brass body for 175 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
 - 2. Class 150, threaded bronze body 300 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
- B. Size 1-1/2 inch to 4 inch:
 - 1. Class 125, flanged iron body, Y pattern with 1/16 inch stainless steel perforated screen.

2.08 PRESSURE REGULATORS

- A. GENERAL REQUIREMENTS
 - 1. Single stage suitable for natural gas.
 - 2. Steel jacket with corrosion resistant components.
 - 3. Provide elevation compensator.
 - 4. End Connections: Threaded for regulators MPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.
- B. LINE PRESSURE REGULATORS AND APPLIANCE REGULATORS INDICATORS
 - 1. Manufacturers:
 - a. Itron
 - b. American Meter Company
 - c. Fisher Control Valves and Regulators
 - d. Maxitrol Company
 - 2. Compliance Requirements:
 - a. Appliance Regulator: ANSI Z21.18/CSA 6.3.
 - b. Line Pressure Regulator: ANSI Z21.80/CSA 6.22.
 - 3. Materials in Contact With Gas:
 - a. Housing: Aluminum, steel (free of non-ferrous metals).
 - b. Seals and Diaphragms: NBR-based rubber.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 PREPARATION

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

3.03 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C. 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.
- F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- G. Provide access where valves and fittings are not exposed.
- H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

- I. Provide support for utility meters in accordance with requirements of utility companies.
- J. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting.
- K. Install valves with stems upright or horizontal, not inverted.
- L. Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.
- M. Sleeve pipes passing through partitions, walls and floors.
- N. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- O. 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 space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Use hangers with 1-1/2 inch 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. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

3.04 APPLICATION

- A. Install unions downstream of valves and at equipment or apparatus connections.
- B. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- C. Install ball valves for throttling, bypass, or manual flow control services.
- D. Provide plug valves in natural gas systems for shut-off service.

3.05 SERVICE CONNECTIONS

- A. Provide new gas service complete with gas meter and regulators.

3.06 SCHEDULES

- A. Pipe Hanger Spacing:
 - 1. Metal Piping:
 - a. Pipe Size: 1/2 inches to 1-1/4 inches:
 - 1) Maximum Hanger Spacing: 6.5 ft.
 - 2) Hanger Rod Diameter: 3/8 inches.
 - b. Pipe Size: 1-1/2 inches to 2 inches:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 3/8 inch.
 - c. Pipe Size: 2-1/2 inches to 3 inches:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 1/2 inch.
 - d. Pipe Size: 4 inches to 6 inches:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 5/8 inch.

END OF SECTION

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**SECTION 23 21 13
HYDRONIC PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic system requirements.
- B. Heating water piping, above grade.
- C. Heating water and glycol piping, above grade.
- D. Chilled water piping, buried.
- E. Chilled water piping, above grade.
- F. Radiant heating piping system.

1.02 REFERENCE STANDARDS

- A. ANSI/FCI 70-2 - Control Valve Seat Leakage 2021.
- B. ASME BPVC-IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators - Welding Brazing and Fusing Qualifications 2019.
- C. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- D. ASME B16.15 - Cast Copper Alloy Threaded Fittings: Classes 125 and 250 2018.
- E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2021.
- F. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2021.
- G. ASME B16.34 - Valves — Flanged, Threaded, and Welding End 2020.
- H. ASME B31.9 - Building Services Piping 2020.
- I. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- J. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service 2019a.
- K. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- L. ASTM A183 - Standard Specification for Carbon Steel Track Bolts and Nuts 2014 (Reapproved 2020).
- M. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2022.
- N. ASTM A536 - Standard Specification for Ductile Iron Castings 1984, with Editorial Revision (2019).
- O. ASTM B32 - Standard Specification for Solder Metal 2020.
- P. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- Q. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- R. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications 2018.
- S. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers 1992 (Reapproved 2022).
- T. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2019.
- U. AWS D1.1/D1.1M - Structural Welding Code - Steel 2020.
- V. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems 2018.
- W. AWWA C606 - Grooved and Shouldered Joints 2015.

- X. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).

1.03 ADMINISTRATIVE REQUIREMENTS

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

1.04 SUBMITTALS

- A. Welders Certificate: Include welders certification of compliance with ASME BPVC-IX.
- B. Product Data:
 - 1. Include data on pipe materials, pipe fittings, valves, and accessories.
 - 2. Provide manufacturers catalog information.
 - 3. Indicate valve data and ratings.
 - 4. Show grooved joint couplings, fittings, valves, and specialties on drawings and product submittals, specifically identified with the manufacturer's style or series designation.
- C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- D. Project Record Documents: Record actual locations of valves.
- E. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified in this section, with minimum 2 years of experience.
- C. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.
- D. Date stamp all castings used for coupling housings, fittings, valve bodies, etc. for quality assurance and traceability.
- E. Welder Qualifications: Certify in accordance with ASME BPVC-IX.

1.06 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.
- 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.

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

- A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
- B. Piping: Provide piping, fittings, hangers, and supports as required, as indicated, and as follows:
 - 1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
 - 2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
 - 3. Grooved mechanical joints are not permitted in any location.
 - a. Accessible locations include those exposed on interior of building, in pipe chases, and in mechanical rooms, aboveground outdoors, and as approved by Architect.
 - b. Grooved mechanical connections and joints comply with AWWA C606.
 - 1) Ductile Iron: Comply with ASTM A536, Grade 65-45-12.
 - 2) Steel: Comply with ASTM A106/A106M, Grade B or ASTM A53/A53M.

- c. Use rigid joints unless otherwise indicated.
 - d. Use gaskets of molded synthetic rubber with central cavity, pressure-responsive configuration, and complying with ASTM D2000, Grade 2CA615A15B44F17Z for circulating medium up to maximum 230 degrees F or Grade M3BA610A15B44Z for circulating medium up to maximum 200 degrees F.
 - e. Provide steel coupling nuts and bolts complying with ASTM A183.
- 4. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
- C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
 - 1. Where grooved joints are used in piping, provide grooved valve/equipment connections if available; if not available, provide flanged ends and grooved flange adapters.
- D. Valves: Provide valves where indicated:
 - 1. Provide drain valves where indicated, and if not indicated provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate or ball valves with cap; pipe to nearest floor drain.
 - 2. Isolate equipment using butterfly valves with lug end flanges or grooved mechanical couplings.
 - 3. Shut off valves for water (HVAC and plumbing) piping 2" and smaller shall be ball type and for 2½" and larger shall be butterfly type.
 - 4. Shut off valves for steam and condensate systems using valves 2" and smaller shall be all bronze body ball valves and for 2½" and up shall be iron body, bronze mounted (IBBM) gate valves. Valves 2½" and larger for steam service shall be rated for minimum 150 psig steam. Steam bypass valves shall be globe type, bronze for 2" and smaller and IBBM for 2½" and larger.
 - 5. For throttling, bypass, or manual flow control services, use globe, ball, or butterfly valves.
 - 6. For throttling and isolation service in chilled and condenser water systems, use only butterfly valves.
 - 7. For shut-off and to isolate parts of systems or vertical risers, use ball or butterfly valves.
 - 8. For throttling service, use plug cocks. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
- E. Welding Materials and Procedures: Comply with ASME BPVC-IX.

2.02 HEATING WATER AND GLYCOL PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, using one of the following joint types:
 - 1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), 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 complying with ASME B16.22, utilizing EPDM, nontoxic synthetic rubber sealing elements. Must be provided with 50 year parts warranty, and 5 year warranty of labor and consequential damages from the contractor and manufacturer.
 - a. Manufacturers:
 - 1) Viega LLC.

2.03 CHILLED WATER PIPING, BURIED

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, black with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.

1. Fittings: ASTM A234/A234M, wrought steel welding type with double layer, half-lapped polyethylene tape.
 2. Joints: Welded in accordance with AWS D1.1/D1.1M.
 3. Casing: Closed glass cell insulation.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) annealed.
1. Fittings: ASME B16.22, wrought copper.
 2. Joints: Solder, lead-free, ASTM B32 HB alloy (95-5 tin-antimony), or tin and silver.
 3. Casing: Closed glass cell insulation.

2.04 CHILLED WATER PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, black; using one of the following joint types:
1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), hard drawn; using one of the following joint types:
1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22, solder wrought copper fittings.
 - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.

2.05 RADIANT HEATING PIPING

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A) annealed.
1. Fittings: ASME B16.22, wrought copper.
 2. Joints: Braze, AWS A5.8M/A5.8 BCuP copper/silver alloy.

2.06 EQUIPMENT DRAINS AND OVERFLOWS

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 galvanized; using one of the following joint types:
1. Threaded Joints: Galvanized cast iron, or ASME B16.3 malleable iron fittings.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), 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.

2.07 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inches: Malleable iron, adjustable swivel, split ring.
 3. Hangers for Cold Pipe Sizes 2 Inches and Greater: Carbon steel, adjustable, clevis.
 4. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
 5. Hangers for Hot Pipe Sizes 6 Inches and Greater: Adjustable steel yoke, cast iron roll, double hanger.
 6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Greater: Steel channels with welded spacers and hanger rods, cast iron roll.
 8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 9. Wall Support for Pipe Sizes 4 Inches and Greater: Welded steel bracket and wrought steel clamp.
 10. Wall Support for Hot Pipe Sizes 6 Inches and Greater: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
 11. Vertical Support: Steel riser clamp.
 12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 13. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 14. Floor Support for Hot Pipe Sizes 6 Inches and Greater: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.

15. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 16. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 17. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
- B. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge-shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.
- C. 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:
1. Bases: High-density polypropylene.
 2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 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 under pipe to top of roofing.

2.08 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

- A. Unions for Pipe 2 Inches and Less:
1. Ferrous Piping: 150 psig malleable iron, threaded.
 2. Copper Pipe: Bronze, soldered joints.
- B. Flanges for Pipe 2 Inches and Greater:
1. Ferrous Piping: 150 psig forged steel, slip-on.
 2. Copper Piping: Bronze.
 3. Gaskets: 1/16 inch thick, preformed neoprene.
- C. Dielectric Connections:
1. Waterways:
 - a. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - b. Dry insulation barrier able to withstand 600-volt breakdown test.
 - c. Construct of galvanized steel with threaded end connections to match connecting piping.
 - d. Suitable for the required operating pressures and temperatures.
 2. Flanges:
 - a. Dielectric flanges with same pressure ratings as standard flanges.
 - b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - c. Dry insulation barrier able to withstand 600-volt breakdown test.
 - d. Construct of galvanized steel with threaded end connections to match connecting piping.
 - e. Suitable for the required operating pressures and temperatures.

2.09 BALL VALVES

- A. Up To and Including 2 Inches:
1. Bronze two piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.
- B. Over 2 Inches:
1. Ductile iron body, chrome plated stainless steel ball, teflon or Virgin TFE seat and stuffing box seals, or flanged ends, rated to 800 psi.

2.10 GENERAL DUTY VALVES

- A. Manufacturers

1. Iron body valves
 - a. Kitz
 - b. Nibco
 - c. Crane
 - d. Ginnell
 - e. Milwaukee
2. Bronze body valves
 - a. Kitz
 - b. Nibco
 - c. Grinnell
 - d. Milwaukee
 - e. Kennedy

2.11 BUTTERFLY VALVES

- A. Body: Cast or ductile iron with resilient replaceable EPDM seat, lug or grooved ends, extended neck.
- B. Disc: Construct of aluminum bronze, chrome plated ductile iron, stainless steel, ductile iron with EPDM encapsulation, or Buna-N encapsulation.
- C. Stem: Stainless steel with stem offset from the centerline to provide full 360-degree circumferential setting.
- D. Operator: Infinite position lever handle with memory stop.

2.12 SWING CHECK VALVES

- A. Up To and Including 2 Inches:
 1. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, threaded ends.
- B. Over 2 Inches:
 1. Iron body, bronze trim, stainless steel, bronze, or bronze faced rotating swing disc, renewable disc and seat, flanged or grooved ends.

2.13 SPRING LOADED CHECK VALVES

- A. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer, or threaded lug ends.

2.14 PRESSURE INDEPENDENT TEMPERATURE CONTROL VALVES AND BALANCING VALVES

- A. Control Valves: Factory-fabricated pressure independent with internal differential pressure regulator (DPRV), which automatically adjusts to normal changes in system pressure and provides 100 percent control valve authority at all positions of the valve.
 1. Maintain proportional and linear flow coil characteristics.
 2. PICV to accurately control the flow from 0 to 100 percent full rated flow with an operating pressure differential range of 3 to 60 psig.
 3. Provide ANSI/FCI 70-2 Class 4 shut-off on all sizes and field serviceable.
 4. Provide control valve to incorporate control, balancing, and flow limiting. Hydronic system pressure independent control valve bodies to comply with ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure and have the following characteristics:
 - a. 2 NPS and Smaller: Class 150 bronze or brass body with union connections, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, and screwed ends with backseating capacity repackable under pressure.
 - b. 2-1/2 NPS and Larger: Class 125 iron or ductile iron body, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, flanged ends with backseating capacity repackable under pressure.
 - c. Pressure Control Seat: Brass construction with vulcanized EPDM.
 - d. Sizing: Line-size.

- e. Fittings and Components: All fittings and components to meet ANSI standards and be compatible with readily available components. 8-inch valves and above to be provided with proper companion flanges.
 - f. Close-Off (Differential) Pressure Rating: Combination of actuator, DPRV action, and trim to provide a minimum close-off pressure rating of 150 percent of total system (pump) head. Provide actuator from the same manufacturer as the pressure independent control valve.
- B. Electronic Actuators: Direct-mounted, self-calibrating type designed for minimum 60,000 full-stroke cycles at rated force.
- C. Provide actuator with visible position indication. Fail positions on power failure to include in-place, open or closed as indicated in the controls specifications.
- 1. Valves: Sized for maximum circuit flow rate and nominally, line-sized.
 - 2. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - 3. Fail-Safe Operation: Mechanical, spring-return mechanism or capacitance return.
 - 4. Power Requirements (Two-Position Spring Return): 24 VAC.
 - 5. Power Requirements (Modulating): Maximum 10 VA at 24 VAC or 8 watts at 24 VDC.
 - 6. Proportional Signal: 0 to 10 VDC or 2 to 10 VDC or 4 to 20 mA, and 2 to 10 VDC position feedback signal.
 - 7. Provide plenum-rated actuators for service above ceilings to possess UL listings and approvals.
 - 8. Temperature Rating: 40 to 104 degrees F.

2.15 FLOW CONTROLS

- A. 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.
- B. Calibration: Control flow within 10 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, minimum pressure 2 psi.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment using jointing system specified.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- F. After completion, fill, clean, and treat systems. See Section 23 25 00 for additional requirements.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install heating water, glycol, chilled water, condenser water, and engine exhaust piping to ASME B31.9 requirements.
- C. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- D. Install piping to conserve building space and to avoid interference with use of space.
- E. Group piping whenever practical at common elevations.
- F. Sleeve pipe passing through partitions, walls, and floors.
- G. Install firestopping to preserve fire resistance rating of partitions and other elements.
- H. Slope piping and arrange to drain at low points.
- I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

- J. Grooved Joints:
 - 1. Install in accordance with the manufacturer's latest published installation instructions.
 - 2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.
- K. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- L. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
 - 2. Support horizontal piping as scheduled.
 - 3. Install hangers to provide minimum 1/2-inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Use hangers with 1-1/2 inches minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 6. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 8. Provide copper plated hangers and supports for copper piping.
- M. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
- N. Provide access where valves and fittings are not exposed.
- O. Use eccentric reducers to maintain top of pipe level.
- P. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welds.
- Q. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting.
- R. Install valves with stems upright or horizontal, not inverted.

3.03 SCHEDULES

- A. Piping Applications
 - 1. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:
 - a. Type K, drawn-temper copper tubing, wrought-copper fittings, and soldered and pressure-seal joints.
 - b. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
 - 2. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
 - a. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - b. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 - 3. Glycol cooling-water piping, aboveground, NPS 2 and smaller, shall be[**any of**] the following:
 - a. Type K, drawn-temper copper tubing, wrought-copper fittings, and soldered pressure-seal joints.

- b. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
 - 4. Glycol cooling-water piping, aboveground, NPS 2-1/2 and larger, shall be[**any of**] the following:
 - a. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 - b. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
 - 5. Glycol cooling-water piping installed belowground and within slabs:
 - a. Schedule 40 Steel Pipe, black with AWWA C105/A21.5 polyethylene jacket, or double layer, half-lapped polyethylene tape.
 - b. Type K, annealed-temper copper tubing, wrought-copper fittings, and **brazed** joints. Use the fewest possible joints.
 - 6. Condensate-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- B. Hanger Spacing for Copper Tubing.
- 1. 1/2 Inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. 1 Inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 3. 1-1/2 Inches and 2 Inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 4. 2-1/2 Inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
- C. Hanger Spacing for Steel Piping.
- 1. 1/2 Inch, 3/4 Inch, and 1 Inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/4 Inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 3. 1-1/2 Inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 4. 2 Inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 5. 2-1/2 Inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 6. 3 Inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 7. 4 Inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.
 - 8. 6 Inches: Maximum span, 17 feet; minimum rod size, 1/2 inch.
 - 9. 8 Inches: Maximum span, 19 feet; minimum rod size, 5/8 inch.
 - 10. 10 Inches: Maximum span, 20 feet; minimum rod size, 3/4 inch.
 - 11. 12 Inches: Maximum span, 23 feet; minimum rod size, 7/8 inch.
 - 12. 14 Inches: Maximum span, 25 feet; minimum rod size, 1 inch.
 - 13. 16 Inches: Maximum span, 27 feet; minimum rod size, 1 inch.
 - 14. 18 Inches: Maximum span, 28 feet; minimum rod size, 1-1/4 inches.
 - 15. 20 Inches: Maximum span, 30 feet; minimum rod size, 1-1/4 inches.

END OF SECTION

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**SECTION 23 21 14
HYDRONIC SPECIALTIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Expansion tanks.
- B. Air vents.
- C. Air separators.
- D. Strainers.
- E. Suction diffusers.
- F. Pump connectors.
- G. Pressure-temperature test plugs.
- H. Balancing valves.
- I. Combination flow controls.
- J. Flow meters.
- K. Relief valves.
- L. Pressure reducing valves.
- M. Glycol system.

1.02 REFERENCE STANDARDS

- A. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard 2020.
- B. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels 2021.

1.03 SUBMITTALS

- A. 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.
- B. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- C. Project Record Documents: Record actual locations of flow controls.
- D. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.04 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.
- 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.

PART 2 PRODUCTS

2.01 EXPANSION TANKS

- A. 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 psi, with flexible EPDM diaphragm or bladder sealed into tank, and steel support stand.
- B. Accessories: Pressure gauge and air-charging fitting, tank drain; precharge to 12 psi.

- C. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.

2.02 AIR VENTS

- A. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
- B. Float Type:
 - 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.
 - 2. Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.

2.03 AIR SEPARATORS

- A. Coalescing Air/Dirt Separators:
 - 1. Manufacturers:
 - a. Spirotherm, Inc; []: www.spirotherm.com/#sle.
 - 2. Tank: Fabricated steel tank; tested and stamped in accordance with ASME BPVC-VIII-1; for 150 psi operating pressure and 270 degrees F maximum operating temperature; subject to the requirements of the application and the 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, threaded to the top of the separator.
 - 5. Inlet and Outlet Connections: Threaded for 2 NPS and smaller; Class 150 flanged connections for 2-1/2 NPS and larger.
 - 6. Blowdown Connection: Threaded.
 - 7. Size: Match system flow capacity.

2.04 STRAINERS

- A. Size 2 inch and Under:
 - 1. Screwed brass or iron body for 175 psi working pressure, Y pattern with 1/32 inch stainless steel perforated screen.
- B. Size 2-1/2 inch to 4 inch:
 - 1. Provide flanged or grooved iron body for 175 psi working pressure, Y pattern with stainless steel perforated screen.
- C. Size 5 inch and Larger:
 - 1. Provide flanged or grooved iron body for 175 psi working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.05 SUCTION DIFFUSERS

- A. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged for 2-1/2 inch and larger, rated for 175 psi working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable 5/32 inch mesh strainer to fit over cylinder strainer, 20 mesh start up screen, and permanent magnet located in flow stream and removable for cleaning.
- B. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.06 PUMP CONNECTORS

- A. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.
 - 1. Maximum Allowable Working Pressure: 150 psig at 120 degrees F.
 - 2. Accommodate the Following:
 - a. Angular Rotation: 15 degrees.
 - b. Force developed by 1.5 times specified maximum allowable operating pressure.

3. End Connections: Same as specified for pipe jointing.
4. Provide necessary accessories including, but not limited to, swivel joints.

2.07 PRESSURE-TEMPERATURE TEST PLUGS

- A. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and Neoprene rated for minimum 200 degrees F.
- B. Application: Use extended length plugs to clear insulated piping.

2.08 BALANCING VALVES

- A. Size 2 inch and Smaller:
 1. Provide ball style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded connections.
 2. Metal construction materials consist of bronze or brass.
 3. Non-metal construction materials consist of Teflon or EPDM.
- B. Size 2.5 inch and Larger:
 1. Provide ball or butterfly style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged or grooved connections.
 2. Valve body construction materials consist of cast iron, carbon steel, or ductile iron.
 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, or NORYL.

2.09 COMBINATION FLOW CONTROLS

- A. Construction: Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet with blowdown/backflush drain.
- B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi.
- C. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.
 1. Accessories: In-line strainer on inlet and ball valve on outlet.

2.10 FLOW METERS

2.11 RELIEF VALVES

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

2.12 PRESSURE REDUCING VALVES

- A. 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 23 21 13.
- B. Materials of Construction:
 1. Valve Body: Constructed of bronze, cast iron, or brass.
 2. Internal Components: Construct of stainless steel and.
- C. Connections:
 1. NPT threaded: 0.50 inch or 0.75 inch.
 2. Soldered: 0.50 inch.
- D. Provide integral check valve and strainer.
- E. Maximum Inlet Pressure: 100 psi.
- F. Maximum Fluid Temperature: 180 degrees F.
- G. Operating Pressure Range: Between 10 psi and 25 psi.

2.13 PRESSURE INDEPENDENT VALVES

- A. Size 2 inch and Smaller:
 1. Provide ball or globe style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded

- connections.
- 2. Metal construction materials consist of bronze or brass.
- 3. Non-metal construction materials consist of Teflon or EPDM.
- B. Size 2.5 inch and Larger:
 - 1. Provide ball, globe, or butterfly style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged or grooved connections.
 - 2. Valve body construction materials consist of cast iron, carbon steel, or ductile iron.
 - 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, or NORYL.

2.14 AUTOMATIC FLOW LIMITING VALVES

- A. Size 0.50 inch to 14 inch:
 - 1. Provide ball or globe style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded connections.
 - 2. Metal construction materials consist of bronze or brass.
 - 3. Non-metal construction materials consist of Teflon, EPDM, or engineered resin.
- B. Size 2.5 inch to 24 inch:
 - 1. Comply with ASME B16.5.
 - 2. Class: 150.
 - 3. Provide ball, globe, or butterfly style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged or grooved connections.
 - 4. Valve body construction materials consist of cast iron, carbon steel, ductile iron, or gray iron.
 - 5. Internal components construction materials consist of aluminum bronze, bronze, Teflon, EPDM, or engineered resin.

2.15 GLYCOL SYSTEM

- A. Mixing Tank: 55 gallon steel drum with fittings suitable for filling and hand pump for charging, rubber hose for connection of hand pump to system.
- B. Storage Tank: Closed type, welded steel constructed, tested and stamped in accordance with ASME BPVC-VIII-1; 100 psi rating; cleaned, prime coated, and supplied with steel support saddles. Construct with tapings for installation of accessories.
- C. Expansion Tank: Diaphragm type with vent fitting with air separator, and automatic air vent.
- D. Air Pressure Reducing Station: Pressure reducing valve with shut-off valves, strainer, check valve and needle valve bypass.
- E. Glycol Solution:
 - 1. Inhibited propylene glycol and water solution mixed 80 percent glycol - 50 percent water, suitable for operating temperatures from minus 40 degrees F to 250 degrees F.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install specialties in accordance with manufacturer's instructions.
- B. Provide manual air vents at system high points and as indicated.
- C. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- D. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- E. Provide valved drain and hose connection on strainer blow down connection.
- F. Provide pump suction fitting on suction side of base mounted centrifugal pumps where indicated. Remove temporary strainers after cleaning systems.

- G. Support pump fittings with floor mounted pipe and flange supports.
- H. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
- I. 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.
- J. Pipe relief valve outlet to nearest floor drain.
- K. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.
- L. Clean and flush glycol system before adding glycol solution.
- M. Feed glycol solution to system through make-up line with pressure regulator, venting system high points. Set to fill at 12 psi.
- N. Perform tests determining strength of glycol and water solution and submit written test results.

3.02 MAINTENANCE

- A. Provide service and maintenance of glycol system for one year from date of Substantial Completion at no extra charge to Owner.
- B. Perform monthly visit to make glycol fluid concentration analysis on site with refractive index measurement instrument. Report findings in detail in writing, including analysis and amounts of glycol or water added.
- C. Explain corrective actions to Owner's maintenance personnel in person.

END OF SECTION

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**SECTION 23 21 23
HYDRONIC PUMPS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. In-line circulators.
- B. Vertical in-line pumps.
- C. Close-coupled pumps.
- D. Base-mounted pumps.

1.02 SUBMITTALS

- 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. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.
- C. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.03 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacture, assembly, and field performance of pumps, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 HVAC PUMPS - 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.
- C. Base Mounted Pumps: Aligned by qualified millwright.
- D. Products Requiring Electrical Connection: Listed and classified by UL or testing agency acceptable to Authority Having Jurisdiction as suitable for the purpose specified and indicated.

2.02 IN-LINE CIRCULATORS

- A. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 175 psi maximum working pressure.
- B. Casing: Cast iron, with flanged pump connections.
- C. Impeller: Non-ferrous keyed to shaft.
- D. Shaft: Stainless steel with bronze sleeve, integral thrust collar.
- E. Electrical Characteristics:
 - 1. Motor: ECM with integrated VFD control.

2.03 VERTICAL IN-LINE PUMPS

- A. Type: Vertical, single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 175 psi working pressure.
- B. Casing: Cast iron, with suction and discharge gauge port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze, fully enclosed, keyed directly to motor shaft or extension.
- D. Shaft: Carbon steel with stainless steel impeller cap screw or nut and bronze sleeve.
- E. Seal: Mechanical seal, 225 degrees F maximum continuous operating temperature.

2.04 CLOSE COUPLED PUMPS

- A. Type: Horizontal shaft, single stage, close coupled, radially split casing, for 125 psi maximum working pressure.
- B. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze, fully enclosed, keyed to motor shaft extension.
- D. Shaft: Stainless steel.
- E. Seal: Mechanical seal, 225 degrees F maximum continuous operating temperature.

2.05 BASE-MOUNTED PUMPS

- A. Type: Horizontal shaft, single stage, direct connected, radially or horizontally split casing, for 125 psi maximum working pressure.
- B. Casing: Cast iron, or ductile iron with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze, fully enclosed, keyed to shaft.
- D. Bearings: Oil lubricated roller or ball bearings.
- E. Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.
- F. Seal: Mechanical seal, 225 degrees F maximum continuous operating temperature.
- G. Drive: Flexible coupling with coupling guard.
- H. Baseplate: Cast iron or fabricated steel with integral drain rim.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.
- C. Provide line sized shut-off valve and pump suction fitting on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
- D. Provide air cock and drain connection on horizontal pump casings.
- E. Provide drains for bases and seals, piped to and discharging into floor drains.
- F. Check, align, and certify alignment of base-mounted pumps prior to start-up.
- G. Install close-coupled and base-mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place.
- H. Lubricate pumps before start-up.

END OF SECTION

SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe and pipe fittings.
- B. Pipe hangers and supports.
- C. Steam piping system.
- D. Steam condensate piping system.

1.02 REFERENCE STANDARDS

- A. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300 2021.
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings 2021.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2021.
- D. ASME B31.1 - Power Piping 2022.
- E. ASME B31.9 - Building Services Piping 2020.
- F. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless 2022.
- G. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2022.
- H. ASTM B32 - Standard Specification for Solder Metal 2020.
- I. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- J. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- K. AWS D1.1/D1.1M - Structural Welding Code - Steel 2020.
- L. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).

1.03 SYSTEM DESCRIPTION

- A. When more than one piping system material is selected, ensure systems components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, unions, and couplings for servicing are consistently provided.
- B. Use unions and flanges downstream of valves and at equipment or apparatus connections. Use dielectric unions where joining dissimilar materials. Do not use direct welded or threaded connections.
- C. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
- D. Use gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- E. Use gate valves for throttling, bypass, or manual flow control services.

1.04 SUBMITTALS

- A. Product Data: Provide data on pipe materials, pipe fittings, valves and accessories. Provide manufacturers catalogue information. Indicate valve data and ratings.
- B. Welders Certificate: Include welders certification of compliance with ASME BPVC-IX.
- C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- D. Project Record Documents: Record actual locations of valves.
- E. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section, with minimum 5 years of documented experience.
- C. Welder Qualifications: Certified in accordance with ASME BPVC-IX.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labelling in place. Inspect for damage.
- 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. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Comply with ASME B31.9 and ASME B31.1 code for installation of piping system.
- B. Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.

2.02 LOW PRESSURE STEAM PIPING (15 PSIG MAXIMUM)

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn.
 - 1. Fittings: ASME B16.18, cast brass, or ASME B16.22 wrought copper.
 - 2. Joints: Solder, lead free, ASTM B32, HB alloy (95-5 tin-antimony), or tin and silver.

2.03 LOW PRESSURE STEAM CONDENSATE PIPING

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn.
 - 1. Fittings: ASME B16.18, cast brass, or ASME B16.22, wrought copper.
 - 2. Joints: Solder, lead free, ASTM B32, HB alloy (95-5 tin-antimony), or tin and silver.

2.04 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 - 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. Hangers for Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
- C. Hangers for Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
- D. Multiple or Trapeze Hangers for Pipe Sizes to 4 inches: Steel channels with welded spacers and hanger rods.
- E. Multiple or Trapeze Hangers for Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods; cast iron roll and stand.
- F. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- G. Wall Support for Pipe Sizes 4 to 5 Inches: Welded steel bracket and wrought steel clamp.
- H. Wall Support for Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp; adjustable steel yoke and cast iron roll.
- I. Vertical Support: Steel riser clamp.
- J. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- K. Floor Support for Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- L. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

- M. 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.

2.05 UNIONS, FLANGES, AND COUPLINGS

- A. Unions for Pipe 2 Inches and Under:
 - 1. Ferrous Piping: 150 psig galvanized malleable iron, threaded.
- B. Flanges for Pipe Over 2 Inches:
 - 1. Ferrous Piping: 150 psig forged steel, slip-on.
 - 2. Gaskets: 1/16 inch thick preformed non-asbestos graphite fiber.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Keep open ends of pipe free from scale and dirt. Whenever work is suspended during construction protect open ends with temporary plugs or caps.
- E. After completion, fill, clean, and treat systems. Refer to Section 23 25 00.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Sleeve pipe passing through partitions, walls, and floors.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- G. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9.
 - 2. Support horizontal piping as indicated.
 - 3. Place hangers within 12 inches of each horizontal elbow.
 - 4. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- H. Provide clearance for installation of insulation and access to valves and fittings.
- I. Slope steam piping one inch in 40 feet in direction of flow. Use eccentric reducers to maintain bottom of pipe level.
- J. Slope steam condensate piping one inch in 40 feet. Provide drip trap assembly at low points and before control valves. Run condensate lines from trap to nearest condensate receiver.

Provide loop vents over trapped sections.

- K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- L. Install valves with stems upright or horizontal, not inverted.

3.03 SCHEDULES

- A. Hanger Spacing for Steel Steam Piping.
 - 1. 1/2 inch: Maximum span, 8 feet; minimum rod size, 1/4 inch.
 - 2. 3/4 inch and 1 inch: Maximum span, 9 feet; minimum rod size, 1/4 inch.
 - 3. 1-1/4 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 4. 1-1/2 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 5. 2 inches: Maximum span, 13 feet; minimum rod size, 3/8 inch.
 - 6. 2-1/2 inches: Maximum span, 14 feet; minimum rod size, 3/8 inch.
 - 7. 3 inches: Maximum span, 15 feet; minimum rod size, 3/8 inch.
 - 8. 4 inches: Maximum span, 17 feet; minimum rod size, 1/2 inch.
 - 9. 6 inches: Maximum span, 21 feet; minimum rod size, 1/2 inch.
 - 10. 8 inches: Maximum span, 24 feet; minimum rod size, 5/8 inch.
 - 11. 10 inches: Maximum span, 26 feet; minimum rod size, 3/4 inch.
- B. Hanger Spacing for Steel Steam Condensate Piping.
 - 1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 - 2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 7. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.
 - 8. 6 inches: Maximum span, 17 feet; minimum rod size, 1/2 inch.
 - 9. 8 inches: Maximum span, 19 feet; minimum rod size, 5/8 inch.
 - 10. 10 inches: Maximum span, 20 feet; minimum rod size, 3/4 inch.

END OF SECTION

SECTION 23 22 14
STEAM AND CONDENSATE HEATING SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Steam traps.
- B. Steam safety valves.
- C. Control valves.

1.02 REFERENCE STANDARDS

- A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels 2021.
- B. ASME B31.9 - Building Services Piping 2020.
- C. ASTM A105/A105M - Standard Specification for Carbon Steel Forgings for Piping Applications 2021.
- D. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings 2004 (Reapproved 2019).
- E. ASTM A276/A276M - Standard Specification for Stainless Steel Bars and Shapes 2017.
- F. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures 1999 (Reapproved 2022).
- G. ASTM A743/A743M - Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application 2021.
- H. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data:
 - 1. Provide for manufactured products and assemblies required for this project.
 - 2. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.
 - 3. Submit schedule indicating manufacturer, model number, size, location, rated capacity, load served, and features for each specialty.
 - 4. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate application, selection, and hookup configuration. Include pipe and accessory elevations.
- D. Operation and Maintenance Data: Include installation instructions, servicing requirements, and recommended spare parts lists.

1.04 QUALITY ASSURANCE

- A. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose indicated.

1.05 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.
- 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.

PART 2 PRODUCTS

2.01 STEAM TRAPS

- A. Steam Trap Applications:
 - 1. Use Float and Thermostatic Traps for:
 - a. Direct steam injected equipment.
 - b. Main headers.
 - c. Branch lines.
 - 2. Use Inverted Bucket Steam Traps for:
 - a. Main headers.
 - b. Branch lines.
 - c. Direct steam injected equipment.
- B. Steam Trap Performance:
 - 1. Select to handle minimum of two times maximum condensate load of apparatus served.
 - 2. Pressure Differentials:
- C. Inverted Bucket Traps: ASTM A126 cast iron or semi-steel body with bolted cover, brass bucket, stainless steel seats and plungers, and stainless steel lever mechanism with knife edge operating surfaces.
 - 1. Rating: 60 psi WSP.
 - 2. Features: Access to internal parts without disturbing piping, top test plug, bottom drain plugs.
 - 3. Accessories:
 - a. Integral inlet strainer of brass.
 - b. Integral inlet check valve.
 - c. Integral bimetal air vent.
- D. Float and Thermostatic Traps: ASTM A126 cast iron or semi-steel body and bolted cover, stainless steel or bronze bellows type air vent, stainless steel or copper float, stainless steel lever and valve assembly
 - 1. Rating: 15 psi WSP.
 - 2. Features: Access to internal parts without disturbing piping, bottom drain plug.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install steam and steam condensate piping and specialties in accordance with ASME B31.9.
- B. Install specialties in accordance with manufacturer's instructions.
- C. Steam Traps:
 - 1. Provide minimum 3/4 inch size on steam mains and branches.
 - 2. Install with union or flanged connections at both ends.
 - 3. Provide gate valve and strainer at inlet, and gate valve and check valve at discharge.
 - 4. Provide minimum 10 inch long, line size dirt pocket between apparatus and trap.

END OF SECTION

**SECTION 23 23 00
REFRIGERANT PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.
- F. Filter-driers.

1.02 REFERENCE STANDARDS

- A. AHRI 710 - Performance Rating of Liquid-Line Driers 2009.
- B. AHRI 730 (I-P) - Flow Capacity Rating of Suction Line Filters and Suction Line Filter Driers 2013 (Reapproved 2014).
- C. AHRI 750 - Thermostatic Refrigerant Expansion Valves 2007.
- D. ASHRAE Std 15 - Safety Standard for Refrigeration Systems 2019, with All Amendments and Errata.
- E. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings 2021.
- F. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes 2018.
- G. ASME B31.5 - Refrigeration Piping and Heat Transfer Components 2022.
- H. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products 2017.
- I. ASTM B88 - Standard Specification for Seamless Copper Water Tube 2020.
- J. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric) 2020.
- K. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service 2020.
- L. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding 2019.
- M. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).

1.03 SYSTEM DESCRIPTION

- A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Provide pipe hangers and supports in accordance with ASME B31.5 unless indicated otherwise.
- C. Liquid Indicators:
 - 1. Use line size liquid indicators in main liquid line leaving condenser.
 - 2. Use line size on leaving side of liquid solenoid valves.
- D. Valves:
 - 1. Use service valves on suction and discharge of compressors.
 - 2. Use gauge taps at compressor inlet and outlet.
 - 3. Use gauge taps at hot gas bypass regulators, inlet and outlet.
- E. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.
- F. Filter-Driers:

1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.
2. Use a filter-drier on suction line just ahead of compressor.
3. Use sealed filter-driers in lines smaller than 1/2 inch outside diameter.
4. Use sealed filter-driers in low temperature systems.
5. Use replaceable core filter-driers in lines of 1/2 inch outside diameter or greater.
6. Use filter-driers for each solenoid valve.

1.04 SUBMITTALS

- A. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- B. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- C. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- D. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- E. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

1.05 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
 1. Fittings: ASME B16.22 wrought copper.
 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.
- B. Copper Tube to 7/8 inch OD: ASTM B88 (ASTM B88M), Type K (A), annealed.
 1. Fittings: ASME B16.26 cast copper.
 2. Joints: Flared.
- C. Pipe Supports and Anchors:
 1. Provide hangers and supports that comply with MSS SP-58.
 - a. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron adjustable swivel, split ring.
 3. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
 4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 5. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 6. Wall Support for Pipe Sizes 4 Inches and Over: Welded steel bracket and wrought steel clamp.
 7. Vertical Support: Steel riser clamp.
 8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 10. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 11. 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.

12. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
 - a. Bases: High density, UV tolerant, polypropylene or reinforced PVC.
 - b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
 - d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
 - e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.

2.02 REFRIGERANT

- A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

2.03 MOISTURE AND LIQUID INDICATORS

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

2.04 VALVES

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

2.05 STRAINERS

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

2.06 FILTER-DRIERS

- A. Performance:
 1. Flow Capacity - Liquid Line: [] ton, minimum, rated in accordance with AHRI 710.
 2. Flow Capacity - Suction Line: [] ton, minimum, rated in accordance with AHRI 730 (I-P).
 3. Pressure Drop: 2 psi, maximum, when operating at full connected evaporator capacity.
 4. Design Working Pressure: 350 psi, minimum.
- B. Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, activated charcoal, and filtration to 40 microns, with secondary filtration to 20 microns; of construction that will not pass into refrigerant lines.
- C. Construction: UL listed.
 1. Replaceable Core Type: Steel shell with removable cap.
 2. Sealed Type: Copper shell.
 3. Connections: As specified for applicable pipe type.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

- E. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- F. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.5.
 - 2. Support horizontal piping as indicated.
 - 3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 - 4. Place hangers within 12 inches of each horizontal elbow.
 - 5. Support vertical piping at every other floor. Support riser piping independently of connected horizontal piping.
 - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 7. Provide copper plated hangers and supports for copper piping.
- G. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- H. Provide clearance for installation of insulation and access to valves and fittings.
- I. Flood piping system with nitrogen when brazing.
- J. Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.
- K. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
- L. Fully charge completed system with refrigerant after testing.

3.02 FIELD QUALITY CONTROL

- A. Test refrigeration system in accordance with ASME B31.5.
- B. Pressure test system with dry nitrogen to 200 psi. Perform final tests at 27 inches vacuum and 200 psi using halide torch. Test to no leakage.

3.03 SCHEDULES

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

END OF SECTION

**SECTION 23 25 00
HVAC WATER TREATMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Materials.
 - 1. System cleaner.
 - 2. Closed system treatment (water).
 - 3. Condenser water system treatment (cooling towers).
 - 4. Open system treatment (humidifiers, air washers, evaporative condensers, small cooling towers, liquid coolers).
- B. By-pass (pot) feeder.
- C. Drip feeder.
- D. Solution metering pump.
- E. Solution tanks.
- F. Agitator.
- G. Liquid level switch.
- H. Conductivity controller.
- I. Water meter.
- J. Solenoid valves.
- K. Timers.
- L. Water softeners.
- M. Test equipment.

1.02 SUBMITTALS

- A. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- B. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.
- D. 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.
- E. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.
- F. 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.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Sufficient chemicals for treatment and testing during required maintenance period.

1.03 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience. Company shall have local representatives with water analysis laboratories and full time service personnel.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 3 years of experience and approved by manufacturer.

PART 2 PRODUCTS

2.01 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.

2.02 MATERIALS

- A. 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).
- B. Closed System Treatment (Water):
 - 1. Sequestering agent to reduce deposits and adjust pH; polyphosphate.
 - 2. Corrosion inhibitors; boron-nitrite, sodium nitrite and borax, sodium tolyltriazole, low molecular weight polymers, phosphonates, sodium molybdate, or sulphites.
 - 3. Conductivity enhancers; phosphates or phosphonates.
- C. Condenser Water System Treatment (Cooling Towers):
 - 1. Sequestering agent to inhibit scaling; phosphonates, sodium polyphosphates, lignin derivatives, synthetic polymer polyelectrolytes, or organic phosphates.
 - 2. Acid to reduce alkalinity and pH; sulphuric acid.
 - 3. Corrosion inhibitor; zinc-phosphate, phosphonate-phosphate, phosphonate-molybdate and phosphonate-silicate, sodium tolyltriazole, or low molecular weight polymers.
 - 4. Biocide chlorine release agents such as sodium hypochlorite or calcium hypochlorite.
- D. Open System Treatment (Humidifiers, Air Washers, Evaporative Condensers, Small Cooling Towers, Liquid Coolers):
 - 1. Sequestering agent to inhibit scaling and corrosion inhibitor; polyphosphate.
 - 2. Biocide chlorine release agents such as sodium hypochlorite or calcium hypochlorite.

2.03 BY-PASS (POT) FEEDER

- A. 2 quart quick opening cap for working pressure of 175 psi.

2.04 SOLUTION METERING PUMP

- A. Positive displacement, diaphragm pump with adjustable flow rate, thermoplastic construction, continuous-duty fully enclosed electric motor and drive, and built-in relief valve.

2.05 SOLUTION TANKS

- A. 30 gallon capacity, polyethylene, self-supporting, 1 gallon graduated markings; molded fiberglass cover with recess for mounting pump, agitator, and liquid level switch.

2.06 AGITATOR

- A. Totally enclosed electric motor, cast iron clamp and motor mount, 1/2 inch diameter coated Type 316 stainless steel propeller.

2.07 LIQUID LEVEL SWITCH

- A. Polypropylene housing with integrally mounted PVC air trap, receptacles for connection to metering pump, and low level alarm.

2.08 CONDUCTIVITY CONTROLLER

- A. Packaged monitor controller with solid state circuiting, five percent accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control function light, output to control circuit and recorder.

2.09 WATER METER

- A. Displacement type cold water meter with sealed, tamper-proof magnetic drive, impulse contact register, single pole, double throw dry contact switch.

2.10 SOLENOID VALVES

- A. Forged brass body globe pattern, normally open or closed as required, explosion-proof and watertight solenoid enclosure, and continuous duty coil.

2.11 TIMERS

- A. Electronic timers, infinitely adjustable over full range, 150 second and five minute range, mounted together in cabinet with hands-off-automatic switches and status lights.

2.12 WATER SOFTENERS

- A. Softener Tank: Glass fiber reinforced plastic tank, overall size, resin capacity 12" dia x 52" height.
- B. Brine Tank: Glass fiber reinforced plastic tank, overall size, salt capacity 250 lb.
- C. Control: Reinforced plastic control valve cycled to regenerate after adjustable metered quantity of water flow.

2.13 TEST EQUIPMENT

- A. Provide white enamel test cabinet with local and fluorescent light, capable of accommodating 4 - 10 ml zeroing titrating burettes and associated reagents.
- B. Provide the following test kits:
 - 1. Alkalinity titration test kit.
 - 2. Chloride titration test kit.
 - 3. Sulphite titration test kit.
 - 4. Total hardness titration test kit.
 - 5. Low phosphate test kit.
 - 6. Conductivity bridge, range 0 - 10,000 micro-ohms.
 - 7. Creosol red pH slide complete with reagent.
 - 8. Portable electronic conductivity meter.
 - 9. High nitrite test kit.

PART 3 EXECUTION

3.01 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.

3.02 CLEANING SEQUENCE

- A. Concentration:
 - 1. As recommended by manufacturer.
 - 2. Fill steam boilers only with cleaner and water.
- B. Hot Water Heating Systems:
 - 1. Apply heat while circulating, slowly raising temperature to 160 degrees F and maintain for 12 hours minimum.
 - 2. Remove heat and circulate to 100 degrees F or less; drain systems as quickly as possible and refill with clean water.
 - 3. Circulate for 6 hours at design temperatures, then drain.
 - 4. Refill with clean water and repeat until system cleaner is removed.
- C. Chilled Water Systems:
 - 1. Circulate for 48 hours, then drain systems as quickly as possible.
 - 2. Refill with clean water, circulate for 24 hours, then drain.
 - 3. Refill with clean water and repeat until system cleaner is removed.
- D. Steam Systems:
 - 1. Apply heat, slowly raising boiler temperature to 160 degrees F and maintain for 12 hours minimum.

2. Cool, then drain as quickly as possible.
 3. Refill with clean water, drain, refill and check for sludge.
 4. Repeat until system is free of sludge.
 5. Apply heat to produce steam for piping system and maintain for 8 hours minimum.
Bypass traps and waste condensate.
- E. Use neutralizer agents on recommendation of system cleaner supplier.
- F. Flush open systems and glycol filled closed systems with clean water for one hour minimum.
Drain completely and refill.
- G. Remove, clean, and replace strainer screens.
- H. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.03 INSTALLATION

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

3.04 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 water coupon rack around circulating pumps with space for 4 test specimens.

3.05 OPEN SYSTEM TREATMENT (HUMIDIFIERS)

- A. Provide two glass mesh feeder bags per unit, suspended in sump, filled with sequestering agent.
- B. Provide drip feeder to feed sequestering agent into sump. Solenoid valve on drip system shall be interlocked with spray pump.
- C. Provide 1/2 inch bleed-off complete with globe valve piped to drain. Locate bleed-off above flood line.
- D. Provide conductivity controller to sample sump water and operate bleed-off solenoid valve. Activate with pump. Pipe to drain.

3.06 CONDENSER WATER SYSTEMS (COOLING TOWERS)

- A. Provide solution pumps to feed sequestering agent and corrosion inhibitor from solution tank into condenser water supply to tower. Provide agitator as required.
- B. Provide conductivity controller to sample condenser water and operate 1 inch solenoid bleed valve and solution pumps. Provide 1/4 inch solenoid valve and piping to blowdown controller sampler wired to open when condensing water pump is operating.
- C. Provide solution pump to feed diluted acid from solution tank into condenser water supply to tower.
- D. Introduce algicide to tower by intermittent slug feed.
- E. Provide water meter in make-up water line to tower, to activate solution pumps for preset time when condenser water pumps are running.
- F. Provide liquid level switch in each solution tank to deactivate solution pump and agitator and sound local alarm bell.
- G. Provide 3/4 inch water coupon rack around circulating pumps with space for 4 test specimens.

3.07 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.

3.08 MAINTENANCE

- A. Perform maintenance work using competent and qualified personnel under the supervision and in the direct employ 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.

END OF SECTION

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**SECTION 23 31 00
HVAC DUCTS AND CASINGS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal ductwork.

1.02 REFERENCE STANDARDS

- A. ASTM A36/A36M - Standard Specification for Carbon Structural Steel 2019.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2022.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- D. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements 2015.
- E. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements 2015.
- F. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements 2015.
- G. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- H. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations 2021.
- I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2021.
- J. SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines 2001.
- K. UL 1978 - Grease Ducts Current Edition, Including All Revisions.
- L. UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. Product Data: Provide data for duct materials.
- B. Shop Drawings: Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work for 2 pressure class and higher systems.
- C. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.04 FIELD CONDITIONS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 PRODUCTS

2.01 DUCT ASSEMBLIES

- A. Regulatory Requirements: Construct ductwork to comply with NFPA 90A standards.
- B. Ducts: Galvanized steel, unless otherwise indicated.
- C. Low Pressure Supply (Heating Systems): 2 inch w.g. pressure class, galvanized steel.
- D. Buried Supply or Return: 1/2 inch w.g. pressure class, concrete encased sheet metal.
 - 1. Fabricate using two gages heavier material than indicated for 2 inch w.g. pressure class.
- E. Medium and High Pressure Supply: 4 inch w.g. pressure class, galvanized steel.
- F. Return and Relief: 3 inch w.g. pressure class, galvanized steel.
- G. General Exhaust: 2 inch w.g. pressure class, galvanized steel.

2.02 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.
- B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - 1. 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.
 - 2. VOC Content: Not more than 250 g/L, excluding water.
 - 3. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
- C. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
- D. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
 - 1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
 - 2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
 - 3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
 - 4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.

2.03 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.
- B. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- C. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- D. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).
- E. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

2.04 MANUFACTURED DUCTWORK AND FITTINGS

- A. Round Ducts: Round lockseam duct with galvanized steel outer wall.
 - 1. Manufacture in accordance with SMACNA (DCS).
- B. Flexible Ducts: Two ply vinyl film supported by helically wound spring steel wire.
 - 1. Insulation: Fiberglass insulation with polyethylene vapor barrier film.
 - 2. Pressure Rating: 10 inches WG positive and 1.0 inches WG negative.
 - 3. Maximum Velocity: 4000 fpm.
 - 4. Temperature Range: Minus 10 degrees F to 160 degrees F.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install in accordance with manufacturer's instructions.
- C. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- D. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- E. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- F. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

- G. Connect terminal units to supply ducts directly or with one foot maximum length of flexible duct. Do not use flexible duct to change direction.
- H. Connect diffusers or light troffer boots to low pressure ducts directly or with 5 feet maximum length of flexible duct held in place with strap or clamp.
- I. At exterior wall louvers, seal duct to louver frame and install blank-out panels.

END OF SECTION

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**SECTION 23 33 00
AIR DUCT ACCESSORIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air turning devices/extractors.
- B. Backdraft dampers - metal.
- C. Backdraft dampers - fabric.
- D. Combination fire and smoke dampers.
- E. Duct access doors.
- F. Duct test holes.
- G. Fire dampers.
- H. Flexible duct connections.
- I. Smoke dampers.
- J. Volume control dampers.

1.02 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- B. NFPA 92 - Standard for Smoke Control Systems 2021.
- C. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations 2021.
- D. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2021.
- E. UL 33 - Safety Heat Responsive Links for Fire-Protection Service Current Edition, Including All Revisions.
- F. UL 555 - Standard for Fire Dampers Current Edition, Including All Revisions.
- G. UL 555C - Standard for Safety Ceiling Dampers Current Edition, Including All Revisions.
- H. UL 555S - Standard for Smoke Dampers Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. Product Data: Provide for shop fabricated assemblies including volume control dampers. Include electrical characteristics and connection requirements.
- B. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers.
- C. Manufacturer's Installation Instructions: Provide instructions for fire dampers.
- D. Project Record Drawings: Record actual locations of access doors and test holes.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Fusible Links: One of each type and size.

1.04 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 AIR TURNING DEVICES/EXTRACTORS

2.02 BACKDRAFT DAMPERS - METAL

- A. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch 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.

2.03 BACKDRAFT DAMPERS - FABRIC

- A. Fabric Backdraft Dampers: Factory-fabricated.

1. Blades: Neoprene coated fabric material.
2. Birdscreen: 1/2 inch nominal mesh of galvanized steel or aluminum.
3. Maximum Velocity: 1000 fpm (5 mps) face velocity.

2.04 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 gage, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- D. Operators: UL listed and labelled 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. Normally Open Smoke Responsive Fire Dampers: Curtain type, closing upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices to ensure positive closure for units mounted horizontally.
- F. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.05 COMBINATION FIRE AND SMOKE DAMPERS - CORRIDOR 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 gage, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- D. Operators: UL listed and labelled 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. Normally Closed Smoke Responsive Fire Dampers: Curtain type, opening by gravity upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure.
- F. Normally Open Smoke Responsive Fire Dampers: Curtain type, closing upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices to ensure positive closure for units mounted horizontally.
- G. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.06 DUCT ACCESS DOORS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Access doors with sheet metal screw fasteners are not acceptable.

2.07 DUCT TEST HOLES

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

2.08 FIRE DAMPERS

- A. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- B. Ceiling (Radiation) Dampers: Galvanized steel, 22 gage, 0.0299 inch frame and 16 gage, 0.0598 inch flap, two layers 0.125 inch ceramic fiber on top side and one layer on bottom side

for round flaps, with locking clip.

1. Box Fitting: Factory-provided 26 gage, 0.0179 inch with field-provided collar.
 2. Rated for one hour service in compliance with UL 555C.
- C. Horizontal Dampers: Galvanized steel, 22 gage, 0.0299 inch frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket.
- D. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for 1.0 inch pressure class ducts up to 12 inches in height.
- E. Multiple Blade Dampers: 16 gage, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- F. Fusible Links: UL 33, separate at 160 degrees F with adjustable link straps for combination fire/balancing dampers.

2.09 FLEXIBLE DUCT CONNECTIONS

- 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 per sq yd.

2.10 SMOKE DAMPERS

- A. Fabricate in accordance with NFPA 90A and UL 555S, and as indicated.
- B. Dampers: UL Class 1 airfoil blade type smoke damper, normally open automatically operated by electric actuator.
- C. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.11 VOLUME CONTROL DAMPERS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Single Blade Dampers:
1. Fabricate for duct sizes up to 6 by 30 inch.
- C. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 by 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
- D. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.
- E. Quadrants:
1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.
 3. Where rod lengths exceed 30 inches provide regulator at both ends.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 31 00 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, combination fire and smoke dampers, and elsewhere as indicated.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. 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 with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- F. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
- G. Demonstrate re-setting of fire dampers to Owner's representative.
- H. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- I. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
- J. 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 2 duct widths from duct take-off.
- K. Provide balancing dampers on high velocity systems where indicated.
- 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

SECTION 23 34 16
CENTRIFUGAL HVAC FANS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Backward inclined centrifugal fans.
- B. Forward curved centrifugal fans.
- C. Airfoil wheel centrifugal fans.
- D. Radial centrifugal fans.
- E. Bearings and drives.
- F. Accessories.

1.02 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.
- C. AMCA 99 - Standards Handbook 2016.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating 2016.
- E. AMCA 300 - Reverberant Room Method for Sound Testing of Fans 2014.
- F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data 2014.
- G. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2021.

1.03 SUBMITTALS

- A. Product Data: Provide data on centrifugal fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- B. Shop Drawings: Indicate assembly of centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Include complete installation instructions.
- D. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Fan Belts: One set for each individual fan.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors, shafts, and bearings from weather and construction dust.

1.05 FIELD CONDITIONS

- A. Permanent fans may not be used for ventilation during construction.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Greenheck.
- B. Loren Cook Company: www.lorencook.com/#sle.
- C. PennBarry, Division of Air System Components: www.pennbarry.com/#sle.
- D. Twin City Fan & Blower: www.tcf.com/#sle.

2.02 PERFORMANCE REQUIREMENTS

- A. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
- B. Sound Ratings: AMCA 301, tested to AMCA 300, and bear AMCA Certified Sound Rating Seal.
- C. Fabrication: Comply with AMCA 99.
- D. Performance Base: Sea level conditions.
- E. Temperature Limit: Maximum 300 degrees F.
- F. Static and Dynamic Balance: Eliminate vibration or noise transmission to occupied areas.

2.03 WHEEL AND INLET

- A. Backward Inclined: Steel or aluminum construction with smooth curved inlet flange, heavy back plate, backwardly curved blades welded or riveted to flange and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.
- B. Forward Curved: Black enameled steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; steel hub swaged to back plate and keyed to shaft with set screw.
- C. Airfoil Wheel: Steel construction with smooth curved inlet flange, heavy back plate die formed hollow airfoil shaped blades continuously welded at tip flange, and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.
- D. Radial: Steel construction with inlet flange, heavy reinforced back plate, plate blades with reinforcing gussets welded or riveted to back plate and flange; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.

2.04 HOUSING

- A. Heavy gage steel, spot welded for AMCA 99 Class I and II fans, and continuously welded for Class III, adequately braced, designed to minimize turbulence with spun inlet bell and shaped cut.
- B. Factory finish before assembly to manufacturer's standard. For fans handling air downstream of humidifiers, provide two additional coats of paint. Prime coating on aluminum parts is not required.
- C. Provide bolted construction with horizontal flanged split housing, where indicated.
- D. Fabricate plug fans without volute housing, in lined steel cabinet..

2.05 BEARINGS AND DRIVES

- A. Bearings: Heavy duty pillow block type, selfgreasing ball bearings, with ABMA STD 9 life at 50,000 hours.
- B. Shafts: Hot rolled steel, ground and polished, with keyway, protectively coated with lubricating oil, and shaft guard.
- C. Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 15 hp and under, selected so required rpm is obtained with sheaves set at mid Fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
- D. Belt Guard: Fabricate to SMACNA (DCS); 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.06 ACCESSORIES

- A. Inlet/Outlet Screens: Galvanized steel welded grid.
- B. Access Doors: Shaped to fit scroll, with quick opening latches and gaskets.
- C. Scroll Drain: 1/2 inch steel pipe coupling welded to low point of fan scroll.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install fans with resilient mountings and flexible electrical leads.
- C. Install flexible connections between fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- D. Provide fixed sheaves required for final air balance.
- E. Provide safety screen where inlet or outlet is exposed.
- F. Pipe scroll drains to nearest floor drain.
- G. Provide backdraft dampers on discharge of exhaust fans and as indicated.

END OF SECTION

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SECTION 23 34 33 AIR CURTAINS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Service window air curtains.
- B. Air curtains.
- C. Air curtains with electric heat.

1.02 REFERENCE STANDARDS

- A. AMCA 220 - Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating 2021.

1.03 SUBMITTALS

- A. Product Data: Manufacturer's descriptive literature for products specified in this section; indicate options specified.
- B. Manufacturer's Instructions: Printed installation instructions for each product specified.
- C. Shop Drawings: Indicate installation and connection details for air curtains.
- D. Operation and Maintenance Data: Manufacturer's printed instructions for operating and maintaining air curtain components.
- E. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Store products of this section in manufacturer's unopened packaging until installation.
- B. Maintain dry, heated storage area for products of this section until installation of products.

1.05 WARRANTY

- A. Supply manufacturer's standard warranty against defects in product workmanship and materials.

PART 2 PRODUCTS

2.01 AIR CURTAINS

- A. Product Description: Self-contained, electrically-operated, air curtain for mounting at head of door openings.
- B. Housing:
 - 1. Material: Galvanized steel.
 - 2. Factory-provided mounting brackets.
 - 3. Finish: Painted epoxy.
- C. Blower Assembly: Heavy-duty motor; . forward curved centrifugal fans, double inlet, double width.
- D. Performance: Tested in accordance with AMCA 220.
- E. Control: ON/OFF control; air curtain turns on when door is opened and off when door is closed.
- F. Operating Noise Level: 54 dBA.
- G. Heat: Heating water coil with control valve.
- H. Thermostat: Wall-mounted.

PART 3 EXECUTION

3.01 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.

3.02 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.

END OF SECTION

**SECTION 23 36 00
AIR TERMINAL UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single-duct terminal units.
 - 1. Single-duct, variable-volume units.

1.02 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.
- C. ASHRAE Std 130 - Laboratory Methods of Testing Air Terminal Units 2016.
- D. ASTM A492 - Standard Specification for Stainless Steel Rope Wire 1995 (Reapproved 2019).
- E. ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope 2019.
- F. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material) 2019.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- J. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems 2008.
- K. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors current edition, including all revisions.

1.03 SUBMITTALS

- A. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- B. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
 - 1. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 to 4 inch wg.
- C. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.
- D. Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.
- E. Project Record Documents: Record actual locations of units and locations of access doors required for access of valving.
- F. 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.
- G. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

- A. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.05 WARRANTY

- A. Provide five year manufacturer warranty for air terminal units.

PART 2 PRODUCTS

2.01 SINGLE-DUCT, VARIABLE-VOLUME UNITS

- A. Manufacturers:
 - 1. Johnson Controls, Inc: www.johnsoncontrols.com/#sle.
 - 2. Price Industries, Inc: www.priceindustries.com/#sle.
 - 3. Titus
 - 4. Siemens
- 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:
 - 1. Minimum 22 gage, 0.0299 inch galvanized steel.
 - a. Assembled with longitudinal lock seam construction.
 - b. Casing leakage to meet ASHRAE Std 130.
 - 2. Air Inlet Collar: Provide round, suitable for standard flexible duct sizes.
 - 3. Unit Discharge: Rectangular, with slip-and-drive connections.
 - 4. Acceptable Liners: ½ inch thick internal fiber-free closed cell insulation. Insulation shall conform to UL 181 for erosion and NFPA 90A for fire, smoke, and melting, and comply with a 25/50 Flame Spread and Smoke Developed Index per ASTM E-84 or UL 723. Additionally, insulation shall comply with Antimicrobial Performance Rating of 0, no observed growth, per ASTM G-21. Material shall be chemically resistant to most hydrocarbon-based solvents.
- D. Damper Assembly:
 - 1. Heavy-gage, 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.
 - a. Air Leakage Past Closed Damper: Maximum two percent of unit maximum airflow at 3 inch wg inlet static pressure, tested in accordance with ASHRAE Std 130.
- E. Hot Water Heating Coil:
 - 1. Coil Casing: Minimum 22 gage, 0.0299 inch galvanized steel, factory-installed on terminal discharge with rectangular outlet, duct connection type.
 - a. Access Door: Gasketed and insulated located on bottom.
 - 2. Coil Fins: Aluminum or aluminum plated fins, mechanically-bonded to seamless copper tubes.
 - 3. Coil leak tested to minimum 350 psig.
 - 4. Base performance data on tests run in accordance with AHRI 410 and units to bear AHRI 410 label.
- F. 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 CFM's.
 - 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.

- d. Room Sensor:
 - 1) Compatible with temperature controls specified.
- 2. Airflow Sensor: Differential pressure airflow device measuring total, static, and wake pressures.
 - a. Signal accuracy: Plus/minus five percent throughout terminal operating range.
- 3. Control Sequence:
 - a. Suitable for operation with duct pressures between 0.25 and 3.0 inch wg inlet static pressure.
 - b. Include factory-mounted and piped, 5-micron filter; and adjustable, velocity-resetting, high-limit control with amplifying relay.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that conditions are suitable for installation.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.
- C. See drawings for the size(s) and duct location(s) of the air terminal units.
- D. Provide ceiling access doors or locate units above easily removable ceiling components.
- E. Support units individually from structure with wire rope complying with ASTM A492 and ASTM A603 in accordance with SMACNA (SRM). See Section 23 0548.
- F. Do not support from ductwork.
- G. Verify that electric power is available and of the correct characteristics.

3.03 ADJUSTING

- A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to zero percent full flow.

3.04 FIELD QUALITY CONTROL

- A. Provide manufacturer's field representative to inspect 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. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Test and adjust controls and safeties.
 - c. Replace damaged and malfunctioning controls and other equipment.
 - d. Remove and replace malfunctioning units and retest as specified above.

3.05 CLEANING

- A. Vacuum clean coils and inside of units.
- B. Install new filters.

END OF SECTION

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**SECTION 23 37 00
AIR OUTLETS AND INLETS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Diffusers.
- B. Registers/grilles.
- C. Critical environment diffusers.
- D. Louvered penthouses.
- E. Roof hoods.

1.02 REFERENCE STANDARDS

- A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating 2012 (Reapproved 2015).
- B. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Air Inlets 2006 (Reaffirmed 2021).
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials 2022.
- D. UL 2518 - Standard for Safety Air Dispersion Systems Current Edition, Including All Revisions.
- E. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials Current Edition, Including All Revisions.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- G. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems 2021.
- H. SMACNA (ASMM) - Architectural Sheet Metal Manual 2012.
- I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2021.

1.03 SUBMITTALS

- 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.

1.04 QUALITY ASSURANCE

- A. Test and rate air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Test and rate louver performance in accordance with AMCA 500-L.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Price Industries
- B. Titus, a brand of Air Distribution Technologies: www.titus-hvac.com/#sle.

2.02 ROUND CEILING DIFFUSERS

- A. Type: Round, adjustable pattern, stamped or spun, multi-core diffuser to discharge air in 360 degree pattern, with sectorizing baffles where indicated. Diffuser collar shall project not more than 1 inch above ceiling. In plaster ceilings, provide plaster ring and ceiling plaque.
- B. Fabrication: Steel with baked enamel finish.

2.03 RECTANGULAR CEILING DIFFUSERS

- A. Type: Provide square, adjustable pattern, stamped, multi-core and multi-louvered diffuser to discharge air in 360 degree pattern.
- B. Connections: Round.

2.04 PERFORATED FACE CEILING DIFFUSERS

- A. Type: Perforated face with fully adjustable pattern and removable face.
- B. Frame: Surface mount type. In plaster ceilings, provide plaster frame and ceiling frame.

2.05 CEILING SLOT DIFFUSERS

- A. Type: Continuous slot, with adjustable vanes for left, right, or vertical discharge.
- B. Fabrication: Aluminum extrusions with factory baked enamel finish.
- C. Frame: 1 inch margin with countersunk screw mounting and gasket, mitered end border.
- D. Plenum: Integral, galvanized steel, insulated.

2.06 DUCT-MOUNTED SUPPLY AND RETURN REGISTERS/LOUVERS

- A. Type: Duct-mounted, rectangular register for round-spiral duct with adjustable pivot-ended blades, end caps, built-in volume damper, and dual cover flanges to lay flush on duct surface regardless of diameter. Performance to match manufacturer's catalog data.

2.07 CEILING SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, one-way deflection.
- B. Frame: 1 inch margin with countersunk screw mounting and gasket.

2.08 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.
- B. Frame: 1 inch margin with countersunk screw mounting.

2.09 CEILING LINEAR EXHAUST AND RETURN GRILLES

- A. Fabrication: Steel with 20 gage, 0.0359 inch minimum frames and 22 gage, 0.0299 inch minimum blades, steel and aluminum with 20 gage, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

2.10 CEILING EGG CRATE EXHAUST AND RETURN GRILLES

- A. Type: Egg crate style face consisting of 1/2 by 1/2 by 1/2 inch grid core.

2.11 WALL SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable blades, 3/4 inch minimum depth, 3/4 inch maximum spacing with spring or other device to set blades, vertical face, single deflection.
- B. Fabrication: Steel with 20 gage, 0.0359 inch minimum frames and 22 gage, 0.0299 inch minimum blades, steel and aluminum with 20 gage, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.

2.12 WALL SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille with two-way deflection.

2.13 WALL EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, vertical face.
- B. Frame: 1 inch margin with countersunk screw mounting.

2.14 WALL GRID CORE EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Fixed grilles of 1/2 by 1/2 by 1/2 inch louvers.
- B. Fabrication: Aluminum with factory baked enamel finish.
- C. Frame: 1 inch margin with countersunk screw mounting.

2.15 LINEAR WALL REGISTERS/GRILLES

- A. Color: As indicated on the drawings.

2.16 LINEAR FLOOR SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined blades with 0 degree deflection, 1/8 by 3/4 inch on 1/4 inch centers, assembled on expanded tubes mandrel construction.
- B. Frame: 1 inch heavy margin frame with countersunk screw mounting, and mounting frame.

2.17 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: As indicated on drawings.
 - 5. Color: To be selected by Architect from manufacturer's standard range.
 - 6. Damper: Provide volume control per manufacturer's recommendations.

2.18 FLOOR SUPPLY REGISTERS/GRILLES

- A. Individually adjustable blades, wide stamped border, single or double blade damper with set screw adjustment.

2.19 LOUVERED PENTHOUSES

- A. Type: All welded assembly with 4 inch deep louvers, mitered corners, sheet aluminum roof, with factory anodized finish.
- B. Color: To be selected by Architect from manufacturer's standard range.

2.20 ROOF HOODS

- A. Fabricate air inlet or exhaust hoods in accordance with SMACNA (DCS).
- B. Fabricate of galvanized steel, minimum 16 gage, 0.0598 inch base and 20 gage, 0.0359 inch hood, or aluminum, minimum 16 gage, 0.0598 inch base and 18 gage, 0.0598 inch hood; suitably reinforced; with removable hood; birdscreen with 1/2 inch square mesh for exhaust and 3/4 inch for intake, and factory prime coat finish.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.
- C. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
- D. Install diffusers to ductwork with air tight connection.
- E. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- F. Paint ductwork visible behind air outlets and inlets matte black. .

END OF SECTION

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**SECTION 23 40 00
HVAC AIR CLEANING DEVICES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Disposable panel filters.
- B. Extended surface high efficiency media filters.
- C. High efficiency particulate air (HEPA) filters.
- D. Filter frames and housings.
- E. Filter gauges.

1.02 REFERENCE STANDARDS

- A. AHRI 851 (SI) - Performance Rating of Commercial and Industrial Air Filter Equipment 2013.
- B. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size 2017, with Addendum (2022).
- C. MIL-STD-282 - Filter Units, Protective Clothing, Gas-Mask Components, and Related Products: Performance-Test Methods 2015b.
- D. UL 586 - High Efficiency, Particulate, Air Filter Units Current Edition, Including All Revisions.
- E. UL 900 - Standard for Air Filter Units Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01 30 00 - 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.
- C. Manufacturer's Installation Instructions: Indicate assembly and change-out procedures.
- D. Operation and Maintenance Data: Include instructions for operation, changing, and periodic cleaning.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Comply with the rating requirements in AHRI 851 (SI).

2.02 DISPOSABLE PANEL FILTERS

- A. Media: UL 900 Class 2, fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive.
 - 1. Thickness: 2 inch.
- B. Performance Rating:
 - 1. Face Velocity: 500 FPM.
 - 2. Initial Resistance: 0.15 inch WG.
 - 3. Recommended Final Resistance: 0.50 inches WG.
- C. Casing: Cardboard frame.

2.03 EXTENDED SURFACE HIGH EFFICIENCY MEDIA FILTERS

- A. Media: Pleated, water-resistant glass fiber with aluminum separators; in 16 gage, 0.0598 inch steel holding frame with corrosion resistant coating.
 - 1. Nominal Size: 24 by 24 by 6 inches deep.
- B. Minimum Efficiency Reporting Value (MERV): [____], when tested in accordance with ASHRAE Std 52.2.
- C. Performance Rating, per ASHRAE Std 52.2:
 - 1. MIL-STD-282 Test 0.3 Micron Dioctyl Phthalate Smoke (DOP) Efficiency: 99 percent.
 - 2. Initial Resistance at 150 fpm Face Velocity: 0.35 inch WG.

3. Recommended Final Resistance: 1.5 inch WG.

2.04 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS

- A. Media: UL 586, pleated, water-resistant glass fiber with separators of aluminum:
 1. Holding Frame: Plywood.
 2. Media to Frame Side Bond: Polyurethane foam.
 3. Face Gasket: Neoprene expanded rubber.
 4. Nominal Size: 24 by 24 by 12 inches deep.
- B. Performance Rating:
 1. MIL-STD-282 Test 0.3 Micron Dioctyl Phthalate Smoke (DOP) Efficiency: 99.97 percent.
 2. Rated Air Flow Capacity at 1.0 inch WG: 1150 CFM.

2.05 FILTER FRAMES AND HOUSINGS

- A. General: Fabricate filter frames and supporting structures of 16 gage, 0.0598 inch galvanized steel or extruded aluminum T-section construction with necessary gasketing between frames and walls.
- B. Standard Sizes: Provide for interchangeability of filter media of other manufacturers; for panel filters, size for 24 by 24 inches filter media, minimum 2 inches thick; for extended surface and high efficiency particulate air filters, provide for upstream mounting of panel filters.
- C. Side Servicing Housings: Flanged for insertion into ductwork, of reinforced 16 gage, 0.0598 inch galvanized steel; access doors with continuous gasketing and positive locking devices on both sides; extruded aluminum tracks or channels for primary secondary filters with positive sealing gaskets.

2.06 FILTER GAUGES

- A. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0-0.5 inch WG, 2 percent of full scale accuracy.
- B. Inclined Manometer: One piece molded plastic with epoxy coated aluminum scale, inclined-vertical indicating tube and built-in spirit level, range 0-3 inch WG, 3 percent of full scale accuracy.
- C. Accessories: Static pressure tips with integral compression fittings, 1/4 inch aluminum tubing, 2-way or 3-way vent valves.

PART 3 EXECUTION

3.01 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 tips 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 tips upstream and downstream of filters.

END OF SECTION

**SECTION 23 51 00
BOILER STACKS**

PART 1 GENERAL

2.01 SECTION INCLUDES

- A. Manufactured breechings.
- B. Single wall metal stacks.
- C. Double wall metal stacks.

2.02 REFERENCE STANDARDS

- A. ANSI Z21.66 - American National Standard for Automatic Damper Devices for Use with Gas-Fired Appliances 2015 (Reaffirmed 2020).
- B. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard 2020.
- C. ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges 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 A181/A181M - Standard Specification for Carbon Steel Forgings, for General-Purpose Piping 2022.
- G. ASTM A193/A193M - Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications 2022a.
- H. ASTM A194/A194M - Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both 2022a.
- I. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service 2022.
- J. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process 2022.
- K. 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 2018a.
- L. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation 2018, with Amendment (2019).
- M. NFPA 31 - Standard for the Installation of Oil-Burning Equipment 2020.
- N. NFPA 82 - Standard on Incinerators and Waste and Linen Handling Systems and Equipment 2019.
- O. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances 2019.
- P. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2021.
- Q. UL 103 - Factory-Built Chimneys for Residential Type and Building Heating Appliances Current Edition, Including All Revisions.
- R. UL 441 - Standard for Gas Vents Current Edition, Including All Revisions.

2.03 DEFINITIONS

- A. Breeching: Vent connector.
- B. Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- C. Smoke Pipe: Round, single wall vent connector.

- D. 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.
- E. 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.

2.04 SUBMITTALS

- A. Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.
- B. 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.
- C. Manufacturer's Instructions: Include installation instructions, and indicate assembly, support details, and connection requirements.

PART 2 PRODUCTS

3.01 MANUFACTURERS

- A. AMPCO by Hart & Cooley, Inc; Model VSI: www.ampcostacks.com/#sle.
- B. DuraVent; DuraStack Pro (DIS2): www.duravent.com/#sle.
- C. Metal-Fab, Inc: www.mtlfab.com/#sle.
- D. Security Chimneys International; Secure Stack Pro (CIX2): www.securitychimneys.com/#sle.
- E. Selkirk Corporation; Model PS: www.selkirkcommercial.com/#sle.
- F. Z-Flex U.S. Inc: www.z-flex.com/#sle.

3.02 BREECHINGS, CHIMNEYS, AND STACKS - GENERAL REQUIREMENTS

- A. Regulatory Requirements:
 - 1. Comply with applicable codes for installation of natural gas burning appliances and equipment.
 - 2. Comply with NFPA 31 for installation of oil burning appliances and equipment.
 - 3. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

3.03 MANUFACTURED BREECHINGS

- A. Provide factory-built, modular connector and manifold system, tested to UL 103 with positive pressure rating.
- B. Assembly to be UL listed for use with building equipment in compliance with NFPA 211.
- C. Fabricate with 1 inch minimum air space between walls and construct inner liner of 304 stainless steel and outer jacket of 304 stainless steel.
 - 1. Protect aluminized steel surfaces exposed to the elements with a minimum of one base coat of primer and one finish coat of corrosion resistant paint suitable for outer jacket skin temperatures of the application.
- D. Design, fabricate, and install gas-tight preventing products of combustion leaking into the building.
 - 1. Securely connect inner joints and seal with factory supplied overlapping V-bands and appropriate sealant in accordance with manufacturer's instructions.
 - 2. System design to compensate for all flue gas induced thermal expansion.

3.04 SINGLE WALL METAL STACKS

- A. Manufacturers:
 - 1. Z-Flex U.S. Inc; []: www.z-flex.com/#sle.
- B. Provide single wall metal stacks, tested to UL 103 and UL listed with positive pressure rating, for use with building heating equipment, in compliance with NFPA 211.

- C. Provide complete venting kit system. ASTM A 959 rated, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
- D. Fabricate with AL29-4C stainless steel.
 - 1. Protect aluminized steel surfaces exposed to the elements with a minimum of one base coat of primer and one finish coat of corrosion resistant paint suitable for outer jacket skin temperatures of the application.

PART 3 EXECUTION

4.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install breechings with minimum of joints. Align accurately at connections, with internal surfaces smooth.
- C. Support breechings from building structure, rigidly with suitable ties, braces, hangers and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA (DCS) for equivalent duct support configuration and size.
- D. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.
- E. For Type B double wall gas vents, maintain UL listed minimum clearances from combustibles. Assemble pipe and accessories as required for complete installation.
- F. Assemble and install stack sections in accordance with NFPA 82, industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement. Connect base section to foundation using anchor lugs.
- G. Level and plumb chimney and stacks.

4.02 SCHEDULES

- A. Breechings, Chimneys and Stacks.
 - 1. Boiler: Steel breeching, Type B stack.
 - 2. Water Heater: Galvanized breeching, Type B stack.
 - 3. Fireplace: Double wall chimney.

END OF SECTION

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**SECTION 23 52 16
CONDENSING BOILERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Manufactured units.
- B. Boiler construction.
- C. Boiler trim.
- D. Fuel burning system.
- E. Factory installed controls.

1.02 REFERENCE STANDARDS

- A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Current Edition.
- B. 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.
- C. ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers 2021.
- D. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI) Current Edition.
- E. NFPA 54 - National Fuel Gas Code 2021.
- F. SCAQMD 1146.1 - Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters 1990, with Amendment (2018).

1.03 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: Burner manifold gas pressure, percent carbon monoxide (CO), percent oxygen (O), percent excess air, flue gas temperature at outlet, ambient temperature, net stack temperature, percent stack loss, percent combustion efficiency, and heat output.
 - 1. Indicate compliance with specified performance and efficiency.
 - 2. Provide results of the following combustion tests:
 - a. Boiler firing rate.
 - b. Gas flow rate.
 - c. Heat input.
 - d. Burner manifold gas pressure.
 - e. Percent carbon monoxide.
 - f. Percent oxides of nitrogen.
 - g. Percent oxygen.
 - h. Percent excess air.
 - i. Flue gas temperature at outlet.
 - j. Ambient temperature.
 - k. Net stack temperature.
 - l. Percent combustion efficiency.
 - m. Heat output.

- 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.

1.04 QUALITY ASSURANCE

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

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect boilers from damage by leaving factory inspection openings and shipping packaging in place until final installation.

1.06 WARRANTY

- A. Provide a five year warranty to include coverage for heat exchanger and 1 year for manufacturer defects.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Natural Gas, Propane, or Combination Natural Gas/Propane:
 - 1. Lochinvar LLC; Crest
 - 2. The Fulton Companies; Endura, Endura+
 - 3. Aerco Benchmark

2.02 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.

2.03 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 and comply with the efficiency requirements of the latest edition of ASHRAE Std 90.1 I-P.
- C. Required Directory Listings:
 - 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: Stainless Steel.
- E. Provide adequate tappings, observation ports, removable panels, and access doors for entry, cleaning, and inspection.
- F. Insulate casing with insulation material, protected and covered by heavy-gauge metal jacket.
- G. Factory apply boiler base and other components, that are subject to corrosion, with durable, acrylic, powder coated, or painted finish.

2.04 BOILER TRIM

- A. ASME rated pressure relief valve.
- 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.

- E. Pressure Switches:
 - 1. High gas pressure.
 - 2. Low gas pressure.
 - 3. Air pressure.
- F. Manual reset high limit.
- G. Boiler Pump:
 - 1. Primary pump, factory supplied and sized for field installation to ensure minimum, continuous circulation through boiler.
 - 2. Where pump is not provided by boiler manufacturer, provide pump in accordance with boiler manufacturer's recommendations.
 - 3. Pump time delay.

2.05 FUEL BURNING SYSTEM

- A. Provide forced draft automatic burner, 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.
 - 2. Forced Draft Design: Mixes combustion air and gas to achieve 90 percent combustion efficiency.
 - 3. Combustion Air Filter: Protects fuel burning system from debris.
- B. Gas Train: Plug valve, safety gas valve, gas-air ratio control valve, and pressure regulator controls air and gas mixture.
- C. Emission of Oxides of Nitrogen Requirements: Comply with SCAQMD 1146.1 for natural gas fired system, as applicable.
- D. Intakes: Combustion air intake capable of accepting direct outside air through a sealed insulated stainless steel intake pipe.

2.06 FACTORY INSTALLED CONTROLS

- A. Option for internal or external (0-10) VDC control.
- B. Temperature Controls:
 - 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. Outside air Temperature Reset: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F outside-air temperature, set supply-water temperature at 140 deg F; at 60 deg F outside-air temperature; set supply-water temperature at 110 deg F.
 - 5. Runtime and Efficiency Optimization:
 - a. Upon a call
 - b. Upon call for heat and demand in the system, a boiler will be enabled at low fire and will modulate according to demand and PID settings up to the base load common value. The base load common shall be field adjustable with a default setting of 40%.
 - c. If the heating load exceeds the output at the base load common firing rate, the next boiler in the sequence will be enabled at low fire. Modular boilers will modulate up and down in parallel as a cohesive unit with infinite modulation points to meet heating load requirements.
 - d. This process continues until all available boilers are enabled, at which point they are released to modulate up to full fire if required.
 - e. As the load decreases, the boilers will be sequentially disabled.
 - f. Boiler sequence order shall be rotated on a programmable number of run hours.
 - g. A boiler in lockout alarm shall be automatically removed from the sequence order.

- h. Lag boilers shall default to local control if the master boiler is fully powered off or removed.
 - i. Each individual boiler shall enable and disable a water circulation control device. The enable of the device, for example a motorized isolation valve or boiler circulator, will be simultaneous with the heat demand for that boiler. The disable of each device will be based on a programmable time delay when the heat demand is no longer present. In variable primary arrangements, the control shall hold the lead boiler isolation valve open at all times.
- C. Electronic PI setpoint/modulation control system.
- D. Microprocessor-based, fuel/air mixing controls.
- E. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
 - 1. Hardwired Points:
 - a. Monitoring: On/off status, common trouble alarm, low water level alarm.
 - b. Control: On/off operation, hot water supply temperature set-point adjustment.
 - 2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

PART 3 EXECUTION

3.01 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 larger than boiler base.
- D. 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.
- E. Provide for connection to electrical service.
- F. Vent combustion fumes in accordance with manufacturer's recommendations.

3.02 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.
 - 3. Instructor: Manufacturer's training personnel.
 - 4. Location: At project site.

END OF SECTION

SECTION 23 62 13
PACKAGED AIR-COOLED REFRIGERANT COMPRESSOR AND CONDENSER UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 REFERENCE STANDARDS

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2023.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems 2019, with All Amendments and Errata.
- C. ASHRAE Std 23.1 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant 2019.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.

1.03 SUBMITTALS

- A. Product Data: Provide rated capacities, weights specialties and accessories, electrical nameplate data, and wiring diagrams. Include equipment served by condensing units in submittal, or submit at same time, to ensure capacities are complementary.
- B. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Include schematic layouts showing condensing units, cooling coils, refrigerant piping, and accessories required for complete system.
- 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 instructions, parts lists, controls, and accessories.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

1.05 WARRANTY

- A. Provide a five year warranty to include coverage for refrigerant compressors.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Carrier Corporation.
- B. Trane Company.
- C. Johnson Controls, Inc
- D. Daikin Manufacturing Company

2.02 MANUFACTURED UNITS

- A. Units: Self-contained, packaged, factory assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressors, condensing coil and fans, integral sub-cooling coil, controls, liquid receiver, wind deflector, and screens.
- B. Construction and Ratings: In accordance with AHRI 210/240. Test in accordance with ASHRAE Std 23.1.
- C. Performance Ratings: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE Std 90.1.

2.03 CASING

- A. House components in welded steel frame with galvanized steel panels with weather resistant, baked enamel finish.
- B. Mount starters, disconnects, and controls in weatherproof panel provided with full opening access doors. Provide mechanical interlock to disconnect power when door is opened.
- C. Provide removable access doors or panels with quick fasteners and piano hinges.

2.04 CONDENSER COILS

- A. Coils: Aluminum fins mechanically bonded to seamless copper tubing. Provide sub-cooling circuits. Air test under water to 425 psig, and vacuum dehydrate. Seal with holding charge of nitrogen.
- B. Coil Guard: Expanded metal with lint screens.

2.05 FANS AND MOTORS

- A. Vertical discharge direct driven propeller type condenser fans with fan guard on discharge. Equip with roller or ball bearings with grease fittings extended to outside of casing.
- B. Weatherproof motors suitable for outdoor use, single phase permanent split capacitor or 3 phase, with permanent lubricated ball bearings and built in current and thermal overload protection.
- C. Horizontal discharge, double width, double inlet forward curved centrifugal type condenser fans, equipped with roller or ball bearings with grease fittings extended to outside of casing, V-belt drive with belt guard.

2.06 COMPRESSORS

- A. Compressor: Hermetic scroll type.
- B. Mounting: Statically and dynamically balance rotating parts and mount on spring vibration isolators.
 - 1. Internally isolate hermetic units on springs.
- C. Lubrication System: Reversible, positive displacement oil pump with oil charging valve, oil level sight glass, and magnetic plug or strainer.
- D. Motor: Constant speed 1800 rpm suction gas cooled with electronic sensor and winding over temperature protection, designed for across-the-line starting. Furnish with starter.
- E. Capacity Reduction Equipment: Suction valve unloaders, with lifting mechanism operated by electrically actuated solenoid valve, with unloaded compressor start; controlled from suction pressure.
- F. Sump Oil Heater: Evaporates refrigerant returning to sump during shut down. Energize heater continuously when compressor is not operating.

2.07 REFRIGERANT CIRCUIT

- A. Provide each unit with one refrigerant circuit, factory supplied and piped.
- B. For each refrigerant circuit, provide:
 - 1. Filter dryer replaceable core type.
 - 2. Liquid line sight glass and moisture indicator.
 - 3. Thermal expansion valve for maximum operating pressure.

4. Insulated suction line.
 5. Suction and liquid line service valves and gauge ports.
 6. Liquid line solenoid valve.
 7. Charging valve.
 8. Discharge line check valve.
 9. Compressor discharge service valve.
 10. Condenser pressure relief valve.
- C. For heat pump units, provide reversing valve, suction line accumulator, discharge muffler, flow control check valve, and solid-state defrost control utilizing thermistors.

2.08 CONTROLS

- A. On unit, mount weatherproof steel control panel, NEMA 250, containing power and control wiring, molded case disconnect switch, factory wired with single point power connection.
- B. For each compressor, provide across-the-line starter, non-recycling compressor overload, starter relay, and control power transformer or terminal for controls power. Provide manual reset current overload protection. For each condenser fan, provide across-the-line starter with starter relay.
- C. Provide safety controls arranged so any one will shut down machine:
1. High discharge pressure switch (manual reset) for each compressor.
 2. Low suction pressure switch (automatic reset) for each compressor.
 3. Oil Pressure switch (manual reset).
- D. Provide the following operating controls:
1. One minute off timer prevents compressor from short cycling.
 2. Low ambient temperature controls.
 3. Hot gas bypass sized for minimum compressor loading on one compressor only, bypasses hot refrigerant gas to evaporator.
- E. Provide controls to permit operation down to 0 degrees F ambient temperature.
1. Thermostat to cycle fan motors in response to outdoor ambient temperature.
 2. Head pressure switch to cycle fan motors in response to refrigerant condensing pressure.
- F. Gauges: Piped for suction and discharge refrigerant pressures and oil pressure for each compressor.
- G. Provide electric solid state microcomputer based room thermostat.
1. Incorporate:
 - a. Automatic switching from heating to cooling.
 - b. Set-up for four separate temperatures per day.
 - c. Instant override of setpoint for continuous or timed period from one hour to 31 days.
 - d. Short cycle protection.
 - e. Programming based on weekdays, Saturday and Sunday.
 2. Display shall include:
 - a. Actual room temperature.
 - b. Programmed temperature.
 - c. Programmed time.
 - d. Duration of timed override.
 - e. System Mode Indication: Heating, cooling, auto, off, fan auto, fan on.
 - f. Stage (heating or cooling) operation.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's installation instructions.
- B. Complete structural, mechanical, and electrical connections in accordance with manufacturer's installation instructions.

- C. Provide connection to refrigeration piping system and evaporators. Refer to Section 23 23 00. Comply with ASHRAE Std 15.

3.02 SYSTEM STARTUP

- A. Supply initial charge of refrigerant and oil for each refrigeration system. Replace losses of oil or refrigerant prior to end of correction period.
- B. Charge system with refrigerant and test entire system for leaks after completion of installation. Repair leaks, put system into operation, and test equipment performance.
- C. Shut-down system if initial start-up and testing takes place in winter and machines are to remain inoperative. Repeat start-up and testing operation at beginning of first cooling season.

END OF SECTION

SECTION 23 64 23
SCROLL WATER CHILLERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Factory-assembled packaged chiller.
- B. Charge of refrigerant and oil.
- C. Controls and control connections.
- D. Chilled water connections.
- E. Electrical power connections.

1.02 REFERENCE STANDARDS

- A. AHRI 550/590 (I-P) - Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle 2020, with Addendum (2022).
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems 2019, with All Amendments and Errata.
- 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. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels 2021.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- F. UL 984 - Hermetic Refrigerant Motor-Compressors Current Edition, Including All Revisions.
- G. UL 1995 - Heating and Cooling Equipment Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate physical size, weight and location of major pieces of equipment to be installed. Notify Architect of any major deviations from the equipment originally specified prior to ordering equipment.

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

1.05 QUALITY ASSURANCE

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

1.06 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.

1.07 WARRANTY

- A. Manufacturer's Warranty: Provide minimum five year warranty to include coverage for materials and labor for compressor.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane
- B. Carrier
- C. Daikin
- D. Johnson Controls

2.02 CHILLER APPLICATIONS

- A. Chiller: Air-Cooled.
 - 1. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.

2.03 CHILLERS

- A. Chillers: Factory assemble and test chiller consisting of compressor(s), compressor motor(s), evaporator, condenser, enclosure, refrigeration circuits(s) and specialties, interconnecting piping, starters, and microprocessor-based controls.
 - 1. Rating: AHRI 550/590 (I-P).
 - 2. Safety: UL 1995 and ASHRAE Std 15.
 - 3. Construction & Testing: ASME BPVC-VIII-1 as applicable for construction type.
 - 4. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., testing firm acceptable to the Authority Having Jurisdiction, or [] as suitable for the purpose specified and indicated.
 - 5. Energy Efficiency: ASHRAE Std 90.1.
 - 6. Enclosures:
 - a. Frame:
 - 1) Heavy-gage steel.
 - 2) Factory apply hot-dipped galvanized or air-dried paint finish.
 - b. Steel Chiller Cabinets:
 - 1) Factory apply baked on enamel, baked on powder paint, or [] finish.
 - c. Electrical Equipment: NEMA 250 or UL 1995 as applicable.
 - 7. Motors: UL 984.

2.04 COMPRESSORS AND EVAPORATOR

- A. Compressors:
 - 1. Construct chiller using fully hermetic scroll type compressors with R410A optimized and dedicated scroll profile.
 - 2. Provide direct drive motor cooled by suction gas with only three major moving parts and a completely enclosed compression chamber which leads to increased efficiency.
 - 3. Each compressor shall have Intermediate Discharge Valves (IDV) or variable volume ratio technology.
 - 4. Each compressor shall have overload protection internal to the compressor.
 - 5. Each compressor shall include: centrifugal oil pump, oil level sight glass and oil charging valve.
 - 6. Each compressor will have crankcase heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
 - 7. Vibration control: Factory installed internal isolators or field installed external isolators.
- B. Evaporator:
 - 1. The evaporator shall be a high efficiency, brazed plate-to-plate type heat exchanger consisting of parallel plates. Braze plates shall be stainless steel with copper braze material.
 - 2. The water side working pressure shall be rated at 150 psig (10.3 bar) and tested at 1.5 times maximum allowable water side working pressure.

3. The refrigerant side working pressure shall be rated at 460 psig (29.6 bar) and tested at 1.1 maximum allowable refrigerant side working pressure.
4. Insulate the evaporator with a minimum of 0.75 inch (K=0.28) UV rated insulation. If the insulation is field installed, the additional money to cover material and installation costs in the field should be included in the bid.
5. Evaporator heaters shall be factory installed and shall protect chiller down to -20°F (-29°C). Contractor shall wire separate power to energize heat tape and protect evaporator while chiller is disconnected from the main power.
6. Provide water drain connection, vent and fittings. Factory installed leaving water temperature control and low temperature cutout sensors.
7. Water connections shall be grooved pipe.
8. Proof of flow shall be provided by the equipment manufacturer, mechanically installed and electrically wired, at the factory of origin.

2.05 WATER-COOLED CONDENSER

- A. Construct condenser coils of microchannel all aluminum brazed fin construction. The condenser coils shall have an integral sub-cooling circuit and shall be designed for at least 650 psig working pressure. Leak tested at 650 psig. Coils can be cleaned with high pressure water.
- B. Condenser coils shall be transverse design. If coils are not transverse design, provide coil protection for shipping.

2.06 AIR-COOLED CONDENSER AND FANS

- A. Construct condenser coils of microchannel all aluminum brazed fin construction. The condenser coils shall have an integral sub-cooling circuit and shall be designed for at least 650 psig working pressure. Leak tested at 650 psig. Coils can be cleaned with high pressure water.
- B. Condenser coils shall be transverse design. If coils are not transverse design, provide coil protection for shipping.
- C. Coil Guards: Provide corrosion proof, louvered panels, heavy gage wire panels, or grilles, factory installed. Provide coil protection for shipping by enclosing entire condenser coil with heavy plastic to prevent coil damage during shipping or rigging.
- D. Fans and Motors:
 1. Fans: Dynamically balance propeller, shrouded-axial, or airfoil type fans of reinforced polymer or glass fiber reinforced composite corrosion resistant construction equipped with sealed, permanently lubricated ball bearings.
 2. Discharge Fan Guards: Corrosion resistant, heavy gage, steel wire.
 3. Discharge Direction: Vertical.
 4. Motors: Direct drive, totally enclosed for outdoor use with current overload protection.

2.07 REFRIGERATION CIRCUITS

- A. Provide multiple independent refrigeration circuit(s) with multiple compressor(s) per circuit.
- B. Provide liquid line shut-off valve, filter-drier, expansion valve, and refrigerant relief device for each independent circuit.

2.08 INTEGRATED MICROPROCESSOR BASED DDC CONTROLS PACKAGE

- A. Pre-wire, assemble, factory mount, and test operating and safety control system consisting of a digital display or gages, on-auto-off switch, motor starters, disconnect switches, power and control wiring. Provide controls, monitoring, programmable set-points, alarms, and BAS as defined below:
 1. Automatic Adjustable Operating Controls:
 - a. Allow system start-up and system operation at all outdoor air temperatures down to -10 degrees F.
 - b. Temperature of chilled water leaving chiller.
 - c. Chiller system capacity control based on set-points and system load.
 - d. Compressor short-cycling prevention.
 - e. Lead/lag for multiple compressors.

- f. Automatic reset on power source failure.
 - g. Load limiting.
 - h. Sequencing of condenser fans.
- 2. Normal Operation Monitoring and Open Cover-less Displays:
 - a. Hours of operation.
 - b. Suction and discharge refrigerant pressures.
 - c. Automatic diagnostics.
 - d. Number of starts.
 - e. On/off compressor status.
 - f. Entering and leaving chilled water temperatures.
 - g. Status of operation.
 - h. Weekly purge cycle totalization if applicable.
 - i. Oil pressure.
- 3. Set-Points:
 - a. Leaving chilled water temperature.
 - b. Date/time.
- 4. Automatic Chiller Shut-Down Safety Controls and Alarm:
 - a. Automatic Reset:
 - 1) Chilled water flow interlock.
 - 2) Voltage protection (over/under).
 - 3) Phase reversal protection.
 - b. Manual Reset:
 - 1) Evaporator low pressure.
 - 2) High motor winding temperature.
 - 3) Low chilled water temperature.
 - 4) Low chilled water flow.
 - 5) High condenser refrigerant discharge pressure.
 - 6) Motor current overload and phase loss.
 - 7) Low oil flow.
 - c. Remote Alarm: Activate remote, audible bell upon safety shutdown of chiller.
- 5. Building Automation System (BAS) Communications via Shielded Cable:
 - a. Minimum Data Transmission to BAS:
 - 1) All system operating conditions.
 - 2) Capacity control information.
 - 3) Safety shutdown conditions.
 - b. Minimum Operating Commands from BAS:
 - 1) Remote unit start/stop.
 - 2) Remote chilled water reset.

2.09 PUMP PACKAGE

- A. Pump package includes: two high head pumps, two VFDs, drainage valves, shut-off valves at entering and leaving connections. The pump package is single point power integrated into the chiller unit power with a separate factory wired control panel. The control of the pump is integrated into the chiller controller. The controller displays both of the evaporator pump starts and run-times. Freeze protection down to an ambient of -20°F (-29°C) is included as standard. The cold parts of the pump package will also be insulated. Designed with redundant pump and VFD, the chiller controls both pumps through a lead/lag and failure/recovery functionality. A variable speed drive is installed in an additional panel to control the pump. The VFD is adjusted upon start up to balance the system flow and head requirements. The purpose is to save on wasted pump energy caused by a traditional balancing valve. The drive has inputs to accept a signal from a BAS for variable primary flow.

2.10 CHILLER MOUNTED STARTER

- A. The starter shall be across-the-line configuration, factory-mounted and fully pre-wired to the compressor motor(s) and control panel.

- B. Unit shall have a single point power connection.
- C. A molded case high fault interrupting capacity circuit breaker shall be factory pre-wired with terminal block power connections and equipped with a lockable external operator handle, making it available to disconnect the chiller from main power.
- D. A control power transformer shall be factory-installed and factory-wired to provide unit control power.
- E. Unit wiring shall run in liquid-tight conduit.
- F. High short circuit current rating (SCCR) of 65 kA.

PART 3 EXECUTION

3.01 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.

3.02 MANUFACTURER'S FIELD SERVICES

- 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.

3.03 CLOSEOUT ACTIVITIES

- A. 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.
- 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.

3.04 MAINTENANCE

END OF SECTION

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SECTION 23 73 13
MODULAR OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Casing construction.
- B. Fan section.
- C. Coil section.
- D. Humidifier section.
- E. Filter section.
- F. Damper section.
- G. Airflow measurement.
- H. Desiccant wheel.
- I. Ultraviolet lights.
- J. Air cleaning systems.
- K. Access section.
- L. Air blender section.
- M. Turning and discharge plenum section.
- N. Controls.
- O. Roof mounting curb.

1.02 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings 2015 (Reaffirmed 2020).
- B. ACGIH - Ultraviolet Radiation: TLV(R) Physical Agents 7th Edition Documentation 2010.
- C. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils 2001, with Addenda (2011).
- D. AHRI 430 (I-P) - Performance Rating of Central Station Air-handling Unit Supply Fans 2020.
- E. AHRI 610 (I-P) - Standard for Performance Rating of Central System Humidifiers for Residential Applications 2014.
- F. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program 2015.
- G. AMCA 99 - Standards Handbook 2016.
- H. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating 2016.
- I. AMCA 300 - Reverberant Room Method for Sound Testing of Fans 2014.
- J. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data 2014.
- K. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating 2018.
- L. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating 2012 (Reapproved 2015).
- M. AMCA 611 - Certified Ratings Program - Product Rating Manual for Airflow Measurement Stations 2015.
- N. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size 2017, with Addendum (2022).
- O. 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.
- P. ASTM B177/B177M - Standard Guide for Engineering Chromium Electroplating 2011 (Reapproved 2021).

- Q. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- R. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- S. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible 2021.
- T. UL (DIR) - Online Certifications Directory Current Edition.
- U. UL 153 - Portable Electric Luminaries Current Edition, Including All Revisions.
- V. UL 508 - Industrial Control Equipment Current Edition, Including All Revisions.
- W. UL 508A - Industrial Control Panels Current Edition, Including All Revisions.
- X. UL 1598 - Luminaires Current Edition, Including All Revisions.
- Y. UL 1812 - Ducted Heat Recovery Ventilators Current Edition, Including All Revisions.
- Z. UL 1995 - Heating and Cooling Equipment Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate the work with other trades for installation of roof mounted air handling units on roof curbs.
- B. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- C. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.04 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.
 - 3. Fans: Performance and fan curves with specified operating point clearly plotted, power, RPM.
 - 4. Sound Power Level Data: Air handling outlet, inlet, 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. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- D. Manufacturer's Instructions: Include installation instructions.
- E. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Fan Belts: One set for each unit.
 - 2. Extra Filters: One set for each unit.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

- C. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.07 WARRANTY

- A. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane Inc.
- B. York International Corporation / Johnson Controls Inc.

2.02 REGULATORY REQUIREMENTS

- A. Comply with NFPA 70.
- B. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

2.03 CASING CONSTRUCTION

- A. Full Perimeter Base Rail:
 - 1. Construct of galvanized steel.
 - 2. Provide base rail of sufficient height to raise unit for external trapping of condensate drain pans.
- B. Casing:
 - 1. Construct of one piece, insulated, 2" double wall panels.
 - 2. Provide mid-span, no through metal, internal thermal break.
 - 3. Construct outer panels of galvanized steel and inner panels of galvanized steel.
 - 4. Paint outer panels with baked enamel finish. Provide weather proofing suitable for outdoor rated equipment.
 - 5. Casing Air Pressure Performance Requirements:
 - a. Able to withstand up to 8 inches w.g. positive or negative static pressure.
 - b. Not to exceed L/240 deflection at 1.5 times design static pressure up to a maximum of plus 8 inches w.g. in positive pressure sections and minus 8 inches w.g. in negative pressure sections. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint.
- C. Access Doors:
 - 1. Construction, thermal and air pressure performance same as casing.
 - 2. Provide surface mounted handles on hinged, swing doors.
 - 3. Provide latches with roller cam mechanisms that ensure a tight seal. Rotating knife-edge or "paw" latches are not acceptable.
 - 4. Where permitted by code, provide double-pane viewing windows in all fan access sections, humidifier sections and upstream of all filter sections. Windows shall be a non-condensing type consisting of a desiccant dehumidification layer. Minimum dimension shall be 8" x 8".
 - 5. Provide VentLok 699 Test Port and gasket in all door systems and as needed to provide at least one port upstream and one port downstream of every coil and filter.
- D. Outdoor Unit Roof:
 - 1. Factory install single layer outer roof above inner roof.
 - 2. Slope at a minimum of 0.25 inches per foot from one side of unit to the other side, or from center to sides of unit.
 - 3. Roof assembly to overhang each unit wall or base rail to overhang curb to facilitate water runoff and prevent water intrusion into roof curb to base connection.
- E. Outside Air and Exhaust Air Weather Hood:
 - 1. Fabricate from same material as casing outer panel.
 - 2. Extend hood past perimeter of unit casing opening so as not to obstruct airflow path.

3. Paint hoods with same finish as external surface of outdoor units.
 4. Provide inlet hood for each fresh air damper with a moisture eliminator to prevent entrainment of water into the unit from outside air.
 5. Provide exhaust hoods for each exhaust air opening.
 6. Size each hood for 100 percent of nominal fresh air damper capacities.
 7. Protect each hood with bird screen to prevent nesting at intake or exhaust air flow paths.
- F. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities. Floors shall be provided with 0.125" aluminum diamond tread plate liner for units 48" and greater in height.
- G. Casing Leakage: Seal joints and provide airtight access doors. Unit shall conform to ASHRAE Standard 111 Class 6 for casing leakage no more than 1.0% of design airflow at 1.25 times design static pressure up to a maximum of +8 inches w.g. in positive pressure sections and -8 inches w.g. in negative pressure sections.
- H. Insulation:
1. Provide minimum thermal value of 13 R throughout.
 2. Completely fill panel cavities in each direction to prevent voids and settling.
 3. Comply with NFPA 90A.
- I. Drain Pan Construction:
1. Provide cooling coil and humidifier sections with an R-13 insulated, double wall, stainless steel drain pan complying with ASHRAE Std 62.1 for indoor air quality and sufficiently sized to collect all condensate.
 2. Slope in two planes to promote positive drainage and eliminate stagnate water conditions.
 3. Locate outlet of sufficient diameter at lowest point of pan to prevent overflow at normal operating conditions.
 4. Provide threaded drain connections constructed of drain pan material, extended sufficient distance beyond the base to accommodate field installed, condensate drain trapping.
 5. Provide drain pan under the complete width and length of cooling coil and humidifier sections. Drain pan shall be full width, and completely extend to next section downstream of cooling coil and humidifier within AHU without growing section length. Pan shall extend a minimum of 12" downstream of cooling coil except where the length is limited due to the installation of UV lighting.
 6. Provide a minimum of 1" clearance between the drain pan and any coil casing, coil support or any other obstruction.
- J. Louvers: Stationary, of galvanized steel or aluminum, 4 inch deep with plenum, nylon bearings, 1/2 inch mesh, 0.04 inch galvanized wire bird screen in aluminum frame, and bearing AMCA Certified Ratings Seal in accordance with AMCA 500-L. Furnish adjustable louvers with hollow vinyl bulb edging on blades and foam side stops to limit leakage to maximum 2 percent at 4 inch wg differential pressure when sized for 2000 fpm face velocity.
- K. Pipe Chase Cabinet
1. Provide external pipe chases with double wall, insulated panels. Pipe chase shall have the same thermal performance as the unit casing.
 2. Provide a perimeter base rail and/or roof curb under the pipe chase(s) that meets requirements for the AHU base rail and/or roof curb.
 3. Manufacturer may ship pipe chases separate from AHU if the chases are provided with lifting lugs for field installation per the AHU base rail requirements. Manufacturer shall provide step-by-step instructions with illustrations for proper pipe chase installation.
- L. Finish:
1. Outdoor Units:
 - a. Coat external surface of unit casing with primer and minimum 1.5 mil, enamel paint finish.
 - b. Comply with salt spray test in accordance with ASTM B177/B177M.
 - c. Color: Manufacturer's standard color.

2.04 FAN SECTION

- A. Type: Direct-drive centrifugal plug type fan, in compliance with AMCA 99.
 - 1. Return fans on AHU-01 will be motorized impeller fans.
- B. Performance Ratings: Determined in accordance with AMCA 210 and labeled with AMCA Certified Rating Seal.
- C. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
- D. Provide, at a minimum, two single width, single inlet (SWSI) plenum fans with 1800 or 1200 RPM motors.
- E. Unless prohibited by code, fans shall not be selected for operation within 85% of MAX Fan RPM and BHP is not to be within 85% of motor nameplate HP. Fan selections shall incorporate a total final filter pressure drop of 1.5" w.c. and a total pre-filter pressure drop of .85" w.c. along with all inlet and discharge opening static pressure drops at design CFM.
- F. Maximum motor HP shall be 30 HP.
- G. Bearings: Self-aligning, grease lubricated, with lubrication fittings extended to exterior of casing with tube and grease fitting rigidly attached to casing.
- H. Mounting:
 - 1. Locate fan and motor internally on welded steel base coated with corrosion resistant paint.
 - 2. Provide access to motor, drive, and bearings through removable casing panels or hinged access doors.
 - 3. Mount base on vibration isolators.
- I. External Motor Junction Box: Factory mount NEMA 4 external junction box and connect to extended motor leads from internally mounted motors.
- J. Motor Wiring Conduit: Factory wire fan motor wiring to the unit mounted variable frequency drive.
- K. Fan Accessories:
 - 1. Variable inlet vanes.
 - 2. Fan inlet screens.
 - 3.
- L. Flexible Duct Connections:
 - 1. For separating fan.
- M. Supply Fan Performance Complying with AHRI 430 (I-P):
- N. Return Fan Performance Complying with AHRI 430 (I-P):
- O. Drives:
 - 1. Comply with AMCA 99.
 - 2. Bearings: Heavy duty pillow block type, ball bearings, with ABMA STD 9 L-10 life at 50,000 hours.
 - 3. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
 - 4. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
 - 5. Belt Guard: Fabricate to SMACNA (DCS); 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.05 COIL SECTION

- A. Casing: Provide access to both sides of coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel with blank off

sheets and sealing collars at connection penetrations.

- B. Provide cooling coils with a maximum face velocity of 450 FPM. Face velocity calculations shall be based on the finned area of the coil. Manufacturer shall guarantee zero carry-over at 500 fpm.
- C. Coils shall be provided with minimum 304 stainless steel coil casing with 304 stainless steel drain pan support structure. Heating coils shall be provided with G-90 galvanized steel coil casings.
- D. Limit the water side pressure drop on water coils to 15 feet. Limit the air side pressure drop on chilled water coils to 0.90" w.c.
- E. Provide at least 18" of access between coils. Provide an easily operable access panel or door, as shown on drawings.
- F. Provide coil segment casing that meets or exceeds casing performance of the unit.
- G. Provide panels that are easily removable with no special tools.
- H. Individual coils shall be removable from the side of the AHU.
- I. Provide a single intermediate vertical coil support on coils with a finned length greater than 62". Provide two vertical supports on coils with a finned length greater than 100" and three vertical supports on coils with a finned length greater than 141".
- J. Provide intermediate drain pans on stacked cooling coils (one at every coil break). Intermediate drain pan shall slope in a minimum of two planes toward a single drain connection.
- K. Provide a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow draining and venting when in-stalled. Extend vent, drain, and coil connections through AHU casing.
- L. Glycol coils shall be operable at 250 psig working pressure and up to 300° F. Factory test water and glycol coils with 325 psig compressed air under water.
- M. Provide glycol coils with a tube OD of 5/8" and material thickness of 0.025". Mechanically expand tubes to form fin bond and provide burnished, work-hardened interior surface. Turbulators shall not be permitted inside water coils.
- N. Provide coils with die-formed, continuous aluminum fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Fins shall be 0.008" thick.
- O. Drain Pans: 24 inch downstream of coil and down spouts for cooling coil banks more than one coil high.
- P. Air Coils:
 - 1. Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.
- Q. Fabrication:
 - 1. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
 - 2. Fins: Aluminum. 0.008" thick.
 - 3. Casing: Die formed channel frame of galvanized steel.
- R. Water Heating Coils:
 - 1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - 2. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.
- S. Water Cooling Coils:
 - 1. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - 2. Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.
 - 3. Cooling coils shall be a maximum of 8 rows and 10 fins per inch.

2.06 HUMIDIFIER SECTION

- A. General: Capacities and selection in accordance with AHRI 610 (I-P).
- B. Steam Grid Humidifier:

1. Stainless steel distribution tube with evenly spaced orifices extended full width of unit, factory mounted in plenum with drain pan for draw-through units.

2.07 FILTERS

- A. General: Provide face loading filters for all filter segment(s). Provide an 18" (minimum) access plenum and access door on the drive side through which face loading filters can be easily loaded. Provide filter sections with minimum of one access door for filter removal, and filter block-offs to prevent air bypass.
- B. Pleated Media Filters:
 1. Media: 4 inch, 100 percent synthetic fibers, continuously laminated to a grid with water repellent adhesive, and capable of operating up to a maximum of without loss of efficiency and holding capacity.
 2. Provide front loading filter tracks for all filters. Side loading racks are unacceptable.
 3. Minimum Efficiency Reporting Value: MERV 11 when tested in accordance with ASHRAE Std 52.2.
- C. Cartridge Filters:
 1. Media: 2 inch, pleated, 8 MERV prefilter and 12 inch closely spaced, pleated, fine-fiber, cartridge filter, sealed into gasketed, metal headers, and capable of operating up to a maximum of 625 fpm for without loss of efficiency and holding capacity.
 2. Provide front loading filter tracks for all filters. Side loading racks are unacceptable.
 3. Minimum Efficiency Reporting Value: 14 MERV when tested in accordance with ASHRAE Std 52.2.
- D. Differential Pressure Gauge:
 1. Provide factory installed dial type differential pressure gauge, flush mounted with casing outer wall, and fully piped to both sides of each filter to indicate status.
 2. Maintain plus/minus 5 percent accuracy within operating limits of 20 degrees F to 120 degrees F.

2.08 DAMPER SECTION

- A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor, return, and exhaust air.
- B. Damper Blades:
 1. Double-skin airfoil design with metal, compressible jamb seals and extruded-vinyl blade-edge seals on each blade.
 2. Self-lubricating stainless steel or synthetic sleeve bearings.
 3. Comply with ASHRAE Std 90.1 I-P for rated maximum leakage rate.
 4. Provide leakage testing and pressure ratings in compliance with AMCA 500-D test methods.
 5. Arrange in parallel or opposed-blade configuration.

2.09 AIRFLOW MEASUREMENT

- A. Flow Meter:
 1. Provide airflow measurement system to directly measure fan airflow or measure differential pressure that can be used to calculate airflow without interfering with submitted airflow performance and noise levels.
 2. Accuracy: Plus/minus 5 percent (device and transmitter) when operating within the stable operating region of the fan curve.
- B. Air Flow Measurement Station:
 1. Provide factory installed, airflow measurement station tested in accordance with AMCA 611 and bearing the AMCA Ratings Seal for Airflow Measurement Performance.
 2. Station Location: Install in outdoor opening to measure airflow.
 3. Damper Blades:
 - a. Galvanized steel or extruded aluminum construction.
 - b. Housed in galvanized steel or extruded aluminum frame and mechanically fastened to a rotating axle rod.

- c. Comply with ASHRAE Std 90.1 I-P for rated maximum leakage rate.
- 4. Measurement Range: Minimum of 15 percent to 100 percent of unit nominal flow.
- 5. Operation: Provide low voltage signal corresponding to actual airflow for controlling and documenting airflow.
- 6. Accuracy: Plus/minus 5 percent.

2.10 DESICCANT WHEEL

- A. Comply with UL 1812 for ducted heat recovery ventilators and UL 1995 for heating and cooling equipment.
- B. Wheel Construction:
 - 1. Desiccant Properties:
 - a. Synthetic matrix with Type III desiccant.
 - b. Immune to water and high humidity.
 - 2. Structurally reinforced with spoke system to minimize wheel deflection.
 - 3. Diameter and perimeter seals.
 - 4. Provide belt drive motor with permanently lubricated ball bearings.
 - 5. Wheel shaft with grease fittings for periodic lubrication.
- C. Maintenance and Access Features:
 - 1. Cleanable wheel matrix.
 - 2. Access doors upstream and downstream of the wheel cassette.
 - 3. Adequate space for cleaning, service, and maintenance.

2.11 ULTRAVIOLET LIGHTS

- A. Tested and recognized by UL 153, UL 1598 and UL 1995 for luminaries, heating, and cooling equipment.
- B. UV-C (Short Wave) Light Array Performance: Provide not less than 190 microwatts per sq inch.
- C. Construction:
 - 1. Factory assemble and test UV-C fixtures in the air handling unit.
 - 2. Materials:
 - a. Provide UV-C resistant polymeric materials or shield from direct or indirect UV-C light with UV-C tolerant material.
 - b. UV-C Fixtures: Stainless steel to resist corrosion.
 - 3. Lamp Life: 9000 hrs minimum with no more than 20 percent loss of output after two years of continuous use.
 - 4. Mount UV-C fixtures on slide-out rack to enable servicing from unit exterior via access door.
 - 5. View Port: Provide with cover to allow viewing of the UV-C light array.
 - 6. Control Panel: Provide a control panel for each UV-C light array.
 - a. Control panel to comply with UL 508A
 - b. Control panel components to be marked with the minimum SCCR (Short Circuit Current Rating).
 - c. Provide control panel enclosure with NEMA 4X rating for prevention of corrosion and water ingress.
 - d. Provide control panel with current sensor to indicate status of the UV-C array.
- D. Safety Features:
 - 1. Treat view port and other windows to assure the UV-C energy emitted is below the threshold limit specified by American Conference of Governmental Industrial Hygienists (ACGIH).
 - 2. Provide a mechanical interlock switch to disconnect power to the UV-C fixtures when the opening of an access door may pose an exposure risk to UV-C light.
 - 3. Provide externally mounted, on-off, disconnect, and shutoff switch with lockout/tagout that disconnects UV-C power and prevents unwanted operation of UV-C lights.

2.12 ACCESS SECTION

- A. Provide to allow for inspection, cleaning, and maintenance of field-installed components.
- B. Construct access doors same as previously specified within this Section.

2.13 AIR BLENDER SECTION

- A. Provide factory engineered air mixers incorporating fixed blades with no moving parts.
- B. Construction:
 - 1. Material: 0.80 inches aluminum, carbon steel, galvanized steel, aluminized steel, or stainless steel.
 - 2. Welded and mechanically fastened.
 - 3. Finish: Galvanized.
- C. Factory install with adequate distances upstream and downstream, based on cataloged performance with a minimum effectiveness of 70 percent outside air or within plus/minus 6 degrees F of theoretical mixed air temperature, at a minimum distance of one mixer diameter downstream of the mixer.
- D. Include pressure loss due to mixer design and mixer-to-plenum ratio in the pressure drop rating for the static air mixer.

2.14 TURNING AND DISCHARGE PLENUM SECTION

- A. Provide plenum to efficiently turn and discharge air.
 - 1. Scale plenum vertical height to accommodate discharge duct height.
 - 2. Scale plenum horizontal length to accommodate required dimensional constraints.

2.15 CONTROLS

- A. Combination VFD - Disconnects:
 - 1. Factory provided combination VFD - disconnect for each fan motor shall be shipped loose and installed on site.
 - 2. After unit installation, VFD shall be started and programmed by a factory trained and employed service technician.
 - 3. Drives are to be provided without by-pass, except in the case of a single-fan application.
 - 4. Disconnects and VFDs are to be in-stalled as close as practical to the fan motor they serve. Where factory-mounted disconnects are to be provided on stacked units, they are to be installed such that they can be reached by a service technician standing beside the unit without the use of a ladder.
 - 5. Where maintenance platforms are anticipated for ease of access to the upper level, disconnects are to be installed adjacent to, and on the same level as, the access door to the motor it serves.
 - 6. Mount VFD-disconnect on fan section externally in a NEMA 3R enclosure within a dedicated controls section or housed fan section.
- B. Factory Installed Direct Digital Control (DDC) System:
 - 1. Factory engineer and test each component.
 - 2. DDC Controller:
 - a. Dedicated, field programmable DDC controller with appropriate point capabilities.

2.16 FACTORY INSTALLED ELECTRICAL ACCESSORIES

- A. In addition to motor power terminals, provide an independent power terminal for convenience receptacles and lights. Provide switches as shown on drawings.
- B. Provide LED (light emitting diode) lights in segments as scheduled or shown on drawings. Provide light switches as scheduled or shown on drawings. Lights shall be constructed of safety glass and suitable for wet lo-cations.
 - 1. Provide a 1-hour timer on external light switches.
- C. Provide a 20A 120V convenience receptacle on supply fan segment. Receptacle shall be powered separately from fan VFD so it remains energized when fan disconnect is open.

2.17 ROOF MOUNTING CURB

- A. Provide insulated factory-fabricated galvanized steel roof curb for outdoor units in accordance with local codes and seismic compliance. Roof curb shall support the full-perimeter of the air handling equipment, including pipe chases.
- B. AHU-01 Roof Vibration Isolation Mounting Curb: 14 inches high galvanized steel, channel frame with gaskets and nailer strips.
- C. AHU-02 Roof Vibration Isolation Mounting Curb: 24 inches high galvanized steel, channel frame with gaskets and nailer strips.
- D. Include roof curb accessories for each roof mounted unit.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- 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 one inch flex between ductwork and fan while running.
- C. Install assembled unit on vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as indicated. Refer to Section 22 05 48. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- D. Provide fixed sheaves required for final air balance.
- E. Make connections to coils with unions or flanges.
- F. Hydronic Coils:
 - 1. Hydronic Coils: Connect water supply to leaving air side of coil (counterflow arrangement).
 - 2. Provide shut-off valve on supply line and lockshield balancing valve with memory stop on return line.
 - 3. Locate water supply at bottom of supply header and return water connection at top.
 - 4. Provide manual air vents at high points complete with stop valve.
 - 5. Ensure water coils are drainable and provide drain connection at low points.
- G. Insulate Coil Headers Located Outside Air Flow as Specified for Piping.

3.02 FIELD QUALITY CONTROL

- A. Final Acceptance Requirements:
 - 1. Use dial indicator gauges to demonstrate fan and motor are aligned.
- B. Coordination of Other Tests and Inspections:
 - 1. And independent Testing, Adjusting, and Balancing agency will test and/or inspect air handling unit.
 - 2. Provide access as required to accommodate timely performance.

3.03 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform systems startup.
- B. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations.
- C. Adjust for proper operation within manufacturer's published tolerances.

3.04 CLOSEOUT ACTIVITIES

- A. 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

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SECTION 23 81 26.13
SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air-source heat pumps.
- B. Water-source heat pumps.
- C. Forced air furnaces.
- D. Air cooled condensing units.
- E. Indoor air handling (fan and coil) units for ducted systems.
- F. Humidifiers.
- G. Controls.

1.02 REFERENCE STANDARDS

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2023.
- B. AHRI 520 - Performance Rating of Positive Displacement Condensing Units 2004.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems 2019, with All Amendments and Errata.
- D. ASHRAE Std 23.1 - Methods for Performance Testing Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Pressures of the Refrigerant 2019.
- E. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size 2017, with Addendum (2022).
- F. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. ASHRAE Std 90.2 - Energy Efficient Design of Low-Rise Residential Buildings 2018, with Addendum (2022).
- H. NEMA MG 1 - Motors and Generators 2021.
- I. NFPA 54 - National Fuel Gas Code 2021.
- J. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems 2021.
- K. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems 2021.
- L. NFPA 211 - Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances 2019.
- M. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- B. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- C. Design Data: Indicate refrigerant pipe sizing.
- D. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- E. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.

- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- G. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.04 WARRANTY

- A. Provide three year manufacturers warranty for solid state ignition modules.
- B. Provide five year manufacturers warranty for heat exchangers.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN

- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
 - 1. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.
- C. Electrical Characteristics:
 - 1. Disconnect Switch: Factory mount disconnect switch on equipment.

2.02 INDOOR AIR HANDLING UNITS FOR DUCTED SYSTEMS

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heating and cooling element(s), controls, and accessories; wired for single power connection with control transformer.
 - 1. Air Flow Configuration: Upflow.
 - 2. Cabinet: Steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
- B. Supply Fan: Centrifugal type rubber mounted with direct or belt drive with adjustable variable pitch motor pulley.
 - 1. Motor: NEMA MG 1; 1750 rpm single speed, permanently lubricated, hinge mounted.
 - 2. Motor Electrical Characteristics:
- C. Air Filters: 1 inch thick urethane, washable type arranged for easy replacement.
- D. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
 - 2. Manufacturers: System manufacturer.

2.03 OUTDOOR UNITS

- A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser.
 - 1. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.
 - 2. Refrigerant: R-410A.
 - 3. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23.1 and UL 207.
- B. Compressor: Hermetic, two speed 1800 and 3600 rpm, AHRI 520 resiliently mounted integral with condenser, with positive lubrication, crankcase heater, high pressure control, motor overload protection, service valves and drier. Provide time delay control to prevent short cycling and rapid speed changes.
- C. Air Cooled Condenser: Aluminum fin and copper tube coil, AHRI 520 with direct drive axial propeller fan resiliently mounted, galvanized fan guard.
- D. Accessories: Filter drier, high pressure switch (manual reset), low pressure switch (automatic reset), service valves and gauge ports, thermometer well (in liquid line).

1. Provide thermostatic expansion valves.
- E. Operating Controls:
 1. Control by room thermostat to maintain room temperature setting.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available and in correct location.
- C. Verify that proper fuel supply is available for connection.

3.02 INSTALLATION

- A. Install in accordance with NFPA 90A and NFPA 90B.
- B. Install refrigeration systems in accordance with ASHRAE Std 15.

END OF SECTION

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**SECTION 23 84 15
STEAM HUMIDIFIERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Dry steam humidifiers.
- B. Steam jacketed distribution manifolds.
- C. Electric resistive steam humidifiers.

1.02 REFERENCE STANDARDS

- A. AHRI 610 (I-P) - Standard for Performance Rating of Central System Humidifiers for Residential Applications 2014.

1.03 SUBMITTALS

- A. Product Data: Provide catalog data indicating rated capacity, dimensions, service connections, electric nameplate data and wiring diagrams.
- B. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- D. Warranty: Submit manufacturer's warranty.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Humidifier Cylinders: One of each type and size.

1.04 QUALITY ASSURANCE

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

1.05 WARRANTY

- A. Provide two two year manufacturer warranty for .

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Armstrong International, Inc
- B. Dri-Steem Corporation
- C. Nortec Industries.
- D. Pure Humidifier Company

2.02 DRY STEAM HUMIDIFIERS

- A. Humidifier: Steam separator type receiving steam at supply pressure and providing separation ahead of control valve, discharging through internal drying and silencing chambers, and distribution manifold at atmospheric pressure; complying with AHRI 610 (I-P).
- B. Body: Cast iron with integral metering valve, separating and drying chambers, and silencing chamber with stainless steel silencing medium.
- C. Separating Chamber: To disengage and remove water droplets and particle matter when operated at maximum capacity.
- D. Control Valve: Steam jacketed parabolic plug, capable of modulating flow of steam over entire stroke of operator with modulating electric operator.
- E. Internal Drying and Silencing Chambers: To receive steam at atmospheric pressure and jacketed by steam at supply pressure.

- F. Distribution Manifold: To provide uniform distribution over entire length, and jacketed by steam at supply pressure. Type 304 stainless steel.
- G. Controls: Temperature switch before steam trap to prevent humidifier from operating before start-up condensate is drained.

2.03 GAS FIRED STEAM HUMIDIFIERS

- A. Water Type: Suitable for use with softened water.
- B. Burner and Heat Exchanger:
 - 1.
 - 2. Burner Type: Natural-gas fired with modulating, low-NOx infrared burner, minimum 80 percent efficient.
 - 3. Gas Train: Safety shutoff valves, gas cock, strainer, and pressure-regulating valve.
 - 4. Ignition: Hot-surface ignition with flame safety system.
 - 5. Combustion Chamber: Sealed with outdoor-air and flue-vent connections.
 - 6. Heat-Exchanger Tank: Cleanable, stainless steel with corrosion-resistant coating.
- C. Cabinet:
 - 1. Powder-coated-steel enclosure. Cabinet is factory insulated for safe operating surface temperature.
 - 2. Enclosure houses internal components, controls, and control panel.
 - 3. Hinged or removable cover, keyed to restrict unauthorized access.
 - 4. Weatherproof outdoor enclosure, with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.
- D. Control Panel:
 - 1. Microprocessor-based control system for modulating control.
 - 2. Factory-wired disconnect switch.
 - 3. Liquid-crystal display.
 - 4. Programmable keypad.
 - 5. Low-voltage control circuit.
 - 6. Diagnostic, maintenance, alarm, and status features.
 - 7. Internal electrical controls prewired to appropriately marked terminals for field connection.
 - 8. Electrical terminals for connection to each controlling device and alarm.
 - 9. NEMA 250, Type 3R, to comply with environmental conditions at installed location.
 - 10. Building Automation System Interface:
 - a. Full Communication System Interface: BACnet
- E. Controls:
 - 1. Solenoid fill valve and automatic drain valves maintain water level. Include bronze inlet strainer, bronze solenoid valve with flow regulator, and fill tee with built-in air gap to prevent back siphoning.
 - 2. Field-adjustable conductivity controller to control drain/fill cycle for flush duration and interval.
 - 3. Controls shall drain tanks if no demand for humidification for more than 72 hours.
 - 4. Set-point adjustment.
 - 5. Float switches for water-level control and to shutdown heat exchanger upon low-water condition.
 - 6. Over-temperature heater shutdown.
 - 7. Aquastat maintains minimum water temperature in tank during short periods of no demand.
 - 8. Thermal safety switch monitors stack temperature for shutdown on overheating.
 - 9. Foaming detection and correction.
- F. Atmospheric Panel Steam Distribution Manifold:
 - 1. Prefabricated steam dispersion grid assembly.
 - 2. Designed for short absorption distance.
 - 3. Suitable for atmospheric steam applications.

4. Extending the full width and height of duct or plenum.
 5. Vertical header with multiple horizontal tubes designed for dry steam injection within short absorption distance.
 6. Nozzles/metered orifices, spaced evenly along distribution tubes, and provide dry and uniform steam distribution.
 7. Distribution panel extending the full width and height of duct or plenum.
 8. Headers and Distribution Tubes:
 - a. Material: Stainless steel, Type 304.
 - b. Insulation: Insulated.
 9. Steam Separator: Separators/baffles, integral to the header, provide condensate-free steam to distribution tubes.
- G. Accessories:
1. Humidistat: Wall mounted.
 2. Duct-mounted, high-limit humidistat.
 3. Airflow switch prevents humidifier operation without airflow.
 4. Some manufacturers do not recommend hoses for outdoor installations. For outdoor installations and as an alternative serving indoor installations, use hard piping. Base piping, valve, and fitting materials on water type used. For reverse osmosis and deionized water applications, match piping, valve, and fitting materials to materials selected for humidifier.
 5. Steam and Condensate Hoses: For interconnection of humidifier to distributor tube(s)/manifold.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance.
- B. Seal all duct and plenum penetrations with flange.
- C. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install stainless-steel drain pan under each manifold mounted in duct.
 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 2. Connect to condensate trap and drainage piping.
 3. Extend drain pan upstream and downstream from tube(s)/manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.
- E. Install tube(s)/manifold supply piping pitched to drain condensate back to humidifier or as recommended by manufacturer.
- F. Equipment Mounting:
 1. Install on manufacturer provided insulated roof curb.
 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- G. Install gas-fired steam generators according to NFPA 54.
- H. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.
- I. Install in accordance with manufacturer's instructions.
- J. Connect dry steam humidifiers to steam supply and to condensate piping. Provide gate valve, inlet strainer, and inverted bucket steam trap. Refer to Section 23 22 13 and Section 23 22 14.

3.02 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 1. Install piping adjacent to humidifiers to allow service and maintenance.

- 2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
- B. Install piping specialties furnished by manufacturer but not factory mounted.
- C. Install piping from safety relief valves to nearest floor drain.
- D. Connect gas piping full size to steam-generator, gas-train inlet with union. Gas piping materials and specialties are specified in Section 231123 "Facility Natural-Gas Piping."
- E. Connect breeching full size to steam-generator outlet. Venting materials are specified in Section 235123 "Gas Vents."
- F. Connect combustion-air inlet to intake terminal using PVC piping with solvent-cemented joints.

END OF SECTION

**SECTION 26 05 00
COMMON REQUIREMENTS FOR ELECTRICAL**

PART 1 GENERAL

1.01 SUMMARY

- A. Section includes general requirements for electrical systems and shall apply to all phases of the work specified, indicated on the drawings and included in this contract. All systems shall be complete and fully functional.
- B. Section includes basic material and methods to complement division 26, 27, and 28 unless noted otherwise.
- C. Electrical contractor shall be fully responsible for all aspects of the electrical systems, material condition, installation, operation, and maintenance until accepted by the owner.
- D. Furnish material, equipment, tools, labor, and services as necessary and required to construct the fully coordinate, complete and properly functioning electrical system as outlined in the Contract Documents.
- E. Section includes:
 - 1. Warranties
 - 2. Questions of interpretation during bidding phase
 - 3. Contract Document discrepancies
 - 4. Value Engineering
 - 5. Definitions
 - 6. Codes and Standards
 - 7. Permits and inspections
 - 8. Materials and equipment manufacturers
 - 9. Quality Assurance
 - 10. Observation of work
 - 11. Coordination
 - 12. Structural coordination
 - 13. Submittals
 - 14. Sleeves
 - 15. Concrete bases
 - 16. Excavation and backfill

1.02 WARRANTIES

- A. Warrant the installed electrical systems are fully coordinated, complete, and properly functioning as outlined in the Construction Documents for a period of one year after date of substantial completion.
- B. Specific equipment may require a longer warranty. Warrant equipment for longer period of time listed in the contract documents. The Project's base warranty period does not supersede any extended warranty periods hereinafter specified.
- C. Repair or replace at no cost to the owner any items which prove defective during the warranty period.
- D. Contractor is responsible to replace any equipment or portion of that equipment whose manufacturer's warranty is based on "time from shipment" which has expired prior to the end of the project's base warranty period or any specified special warranty periods(s). Extended manufacturer's warranties may be utilized to provide coverage for the required warranty periods(s) and shall be included in the contractor's bid.
- E. The contractor agrees not to void or allow subcontractors to void any warranty regarding products installed as a part of this project.
- F. Upon written notice from the Architect or Owner, promptly remedy and defects occurring within the Project's base warranty period from the date as specified by the Architect.

1.03 QUESTIONS OF INTERPRETATION DURING BIDDING PHASE

- A. Thoroughly review all portions of the Contract Documents and fully coordinate items which will be utilized on this Project, including their proper installation.
- B. No one portion of the Contract Document takes precedent over another portion.
- C. If questions arise during the bidding process regarding the meaning of any portion of the contract comment, the prospective bidder shall submit the questions to the Architect/Engineer for clarification prior to date of last addendum.
- D. Interpretation or clarification of the contract documents will be published by addenda.
- E. Verbal interpretation or explanations not issued in the addenda shall not be considered part of the contract documents.
- F. Where conflicts exist between within the contract documents or between the contract documents and adopted codes the contractor shall bid the more expensive method and products.
- G. The Architect/Engineer shall be the sole judge regarding interpretations of conflicts.
- H. The contractor shall confirm their equipment suppliers have thoroughly reviewed all portions of the contract documents and reported any ambiguities, discrepancies, errors, inconsistencies or omissions to the Architect in writing prior to the last addendum date. Any items not identified shall be bid as the most expensive option.

1.04 CONTRACT DOCUMENT DISCREPANCIES

- A. Thoroughly review all portions of the Contract Documents to fully coordinate electrical items, including their proper installation, which will be utilized on this project. Provide costs for incidental work and materials needed to complete the installation based on field conditions.
- B. If any conflicts or ambiguities appear in the contract documents, request clarification from the Architect/Engineer before proceeding with work.
- C. If the contractor fails to report or request clarification of contract documents discrepancies or ambiguities, no excuse will be entertained for failure to perform work to the satisfaction of the Architect/Engineer.

1.05 VALUE ENGINEERING

- A. Value engineering items proposed by the contractor or engineer shall be fully coordinated with each trade/contractor. Proposed cost savings for each item shall include costs savings and cost increases for all affected trades. Proposed item shall include:
 - 1. Specification (section and paragraph) and drawings (sheet, detail, and or schedule) which references related VE item.
 - 2. Complete information on the proposed VE material or equipment as required to allow the Engineer and Owner to make an informed decision.
 - 3. Denote variations from the originally specified material or equipment and any associated benefit or detriments to the owner.
 - 4. List operational energy efficiency differences and change in systems useful life.
 - 5. Provide calculations as required to show performance of proposed product is equivalent to product specified.
 - 6. Contractor is responsible to provide the burden of proof regarding the appropriateness for the intended use of a product. The engineer is not responsible for performing any additional research to determine the appropriateness of the submitted item.

1.06 DEFINITIONS

- A. The following definitions shall apply throughout the contract documents.
 - 1. Code: Applicable national, state and local codes
 - 2. Mechanical: Plumbing, HVAC, & fire protection work required by the Contract Documents
 - 3. Electrical: Electrical and fire alarm work required by the Contract Documents
 - 4. Contractor: Any Contractor performing work required by the Contract Documents
 - 5. Indicated: Noted, scheduled or specified
 - 6. Selected: Selected by the Architect/Engineer.

7. Provide: Furnish, install, connect and tested complete and ready for use
8. Furnish: Supply and deliver to the site ready for installation
9. Install: Install complete, per Contract Documents and manufacturer's requirements.
10. Finished Spaces: Spaces that are accessible to building occupants at some time except those spaces such as mechanical/electrical/elevator equipment rooms, janitor closets, furred spaces, pipe and duct shafts, unconditioned spaces immediately below the roof, void spaces above ceilings, crawlspaces, and utility tunnels.
11. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
12. Exposed, Exterior Installations: Exposed to view outdoors, or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
13. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
14. 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.

1.07 CODES AND STANDARDS

- A. The work shall be performed by persons skilled in the trade involved and shall be done in a manner consistent with normal industry standards.
- B. All references to industry standards in the construction documents refer to the most current edition of that standard unless the adopted code references a different edition.
- C. The work shall conform to all applicable section of currently adopted codes and of the following standards. Reference the architectural code review sheet for clarification.
 1. Safety and Health Regulations for Construction
 2. Occupational Safety and Health Standards (OSHA), National Consensus Standards and Established Federal Standards
 3. Factory Mutual Global Engineering (FMG)
 4. Underwriters' Laboratories, Inc. (UL)
 5. National Electrical Manufacturers Association (NEMA)
 6. Institute of Electrical and Electronics Engineers (IEEE)
 7. Insulated Power Cable Engineers Association (IPCEA)
 8. Telecommunications Industry Association (TIA)
 9. Building Industry Consulting Service International (BICSI)
 10. Owners written design standards
 11. Applicable national, state and local codes
- D. Where conflicts exist between code, manufacturers installation instructions and/or contract documents, the most stringent requirement shall take precedence. Modifications required by conflicts to the electrical system shall be a no cost change to the project.

1.08 PERMITS AND INSPECTIONS

- A. The contractor shall obtain and pay for all permits, fees, and licenses required for the construction and acceptance of the Electrical system by the Engineer and authority having jurisdiction.
- B. The contractor shall call for, obtain and pay for any and all inspections and re-inspections required for the work indicated in the contract documents.
- C. Contractor shall coordinate with the local utility and follow local rules and regulations. Contractor shall pay for fees and services used prior to final completion..
- D. If a portion of the electrical system does not pass tests or inspections, make required corrections and arrange for re-inspection.
- E. Contact AHJs and coordinate the requirements, timing, and and completion of all required inspections.
- F. Furnish all material, equipment tools, temporary connections, labor, and services as required by the AHJ(s) to complete the inspection.

1.09 MATERIALS AND EQUIPMENT MANUFACTURERS

- A. Options in selecting materials and equipment are limited by requirements of the contract documents and governing regulations. They are not controlled by industry traditions or procedures experienced on previous construction projects.
- B. Materials and equipment shall be provided in accordance with the following:
 - 1. Primary design products: Primary design products are those products around which the project was designed in terms of capacity, performance, physical size and quality.
 - 2. Primary design products are indicated by use of a single manufacturer's name, model number or similar data on drawings or schedules or within the specifications.
 - 3. Provide primary design products unless substitutions are made in accordance with the following paragraphs.
 - 4. Acceptable equivalent substitutions: acceptable equivalent substitutions are products of manufacturers other than those listed for the primary design products. Equivalent acceptable substitutions shall meet each of the following requirements:
 - a. The product shall be manufactured by one of the acceptable manufacturers listed in the project manual, drawings or addenda.
 - b. The product shall meet or exceed the requirements of the contract documents in terms of quality, performance, suitability, appearance, and physical characteristics.
 - c. The contractor providing the substitutions shall bear the total cost of changed due to substitutions. These costs may include additional compensation to the Architect/Engineer for redesign and evaluation services, increased cost of work by the owner or other contractors, and similar considerations.
 - d. Equipment whose physical size is larger than those specified and would hinder proper access and maintenance will not be considered.
 - 5. Performance Requirements: Where the contract documents list performance requirements or describe a product or assembly generically, provide products that comply with the specific requirements indicated and that are recommended by the manufacturer for the respective application.
 - 6. Compliance with Standards, Codes and Regulations: Where the specifications require only compliance with an imposed standard, code or regulation, the Contractor has the option of selecting a product that complies with specification requirements, including the standards, codes and regulations.
- C. Prior approvals will be reviewed for acceptability of manufacturer being proposed. Inclusion of product manufacturer is not in any way a replacement for the required shop drawings. Nor is it a guarantee that product submitted will be deemed an acceptable product. Provide products the meet or exceed the requirements of the contract documents.
- D. The contractor shall bear the burden of proof regarding the equivalency of a product.

1.10 ALTERNATE CONSTRUCTION

- A. Refer to Division 0 of the specifications for alternate constructionwork to determine the increase or decrease in the contract price to the base proposal for each alternate required.
- B. Coordinate and modify associated surrounding work as required to accommodate the alternate construction.

1.11 QUALITY ASSURANCE

- A. Conform to the requirements of NFPA 70.
- B. Products; listed and classified by Underwriters Laboratories or testing firm acceptable to the authority having jurisdiction as suitable for the purpose specified and indicated.

1.12 OBSERVATION OF WORK

- A. The Engineer's site visits will consist of visual observations of the construction, and the equipment and materials used therein, to permit the Engineer to render their professional opinion as to the Contractor's conformance to the intent of the Bid Documents. Given the inherent limitations of such inspections, they shall not be relied upon by any party as acceptance of the work, nor shall they relieve any party from fulfillment of customary and

contractual responsibilities and obligations.

- B. Although Engineer may confer with the Contractor regarding interpretation of plans and specifications, such assistance shall not relieve Contractor of any responsibility for the work.
- C. The fact that the Engineer has failed to observe faulty work, or work done which is not in accordance with the drawings and specifications, shall not relieve the Contractor from responsibility for correcting such work without additional compensation.
- D. Prior to the engineer's final construction observation (final punch visit) the contractor shall provide the engineer a half sized set of construction documents with devices and equipment highlighted to show device/equipment has been installed and is complete. Items not highlighted shall be noted as to what work still remains to be completed.
- E. Construction observation report(s) may recommend rejection of the work which, in the Engineer's professional opinion, does not conform to the intent of the Contract Documents or applicable code requirements.
- F. Compliance with OSHA requirements or other statutory safety requirements is the responsibility of the Contractor.
- G. Prior to the Engineer's final construction observation the contractor shall provide the Engineer with the contractor's observation report that was made prior to the Engineer's visit.

1.13 COORDINATION

- A. Coordinate arrangement, mounting and support of electrical equipment;
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. To allow proper access to all equipment requiring access.
- B. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.
- C. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.
- D. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.
- E. Coordinate electrical service connections to components furnished by utility companies.
 - 1. Coordinate installation and connection of exterior underground and overhead utilities and services, including provision for electricity-metering components.
 - 2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.
- F. Provide offsets and elevation changes in conduit, cable tray, and other electrical components as required to complete the layout and coordination process.
- G. Be thoroughly familiar with all portions of the Contract Documents to ensure electrical equipment, material, and work are fully coordinated with each contractor's equipment, material, and work at this site.
- H. Where existing electrical items require relocation to allow other electrical work, or work of other trades to proceed, relocate items as require. Maintain continuity of systems and required clearance.
- I. The contractor shall be thoroughly familiar with each portion of the contract documents to ensure that electrical equipment, material and work are coordinated with other aspects of this project.

1.14 STRUCTURAL COORDINATION

- A. In cases where the Contractor determines that superimposed loads such as suspended or floor mounted equipment exist which exceed design loads indicated on structural documents, The Contractor shall submit load data to Architect/Engineer for review prior to proceeding with work.
- B. Distribute the maximum load hung from any structural member over the member's tributary area in a way that the design superimposed dead loads listed in structural documents are not exceeded. The Contractor shall coordinate the loads and provide additional support or distribution framing as required achieving the allowable load distribution.
- C. Connections of systems designed by Contractor's engineer such as, but not limited to mechanical, electrical, plumbing loads are assumed to impose vertical and/or horizontal loads on the base building structural members without generating torsion in the supporting structural members. Contractor is responsible for furnishing and installing all supplementary bracing members as required to prevent torsion on the base building structure.

1.15 SUBMITTALS

- A. In addition to the requirements of division 1; provide submittals as indicated in individual sections. Before equipment is ordered obtain a "No exceptions taken" or an "exceptions taken as noted" response from the Architect and Engineer.
- B. Coordinate timing of submittals in accordance with Division 1 requirements, to provide adequate time for design professionals' review. Submit shop drawings and product data grouped together in complete submittals. Items submitted individually for each piece of equipment will not be accepted.
- C. The contractor shall be responsible for items submitted for review that will impact the coordination process. Submittals that pass the review process and are required to be modified to achieve coordination shall be modified by the contractor at no cost to the project.
- D. Submittals shall contain values for items listed in the schedules or specified elsewhere. Values shall be in units to match those specified in the contract documents.
- E. Data sheets and shop drawings shall be marked to clearly identify sizes or options of submitted equipment. Also include required clearances around equipment required for access and maintenance.
- F. Submit a specification compliance review where indicated in individual sections.
 - 1. At each paragraph of the specification indicate in the left hand margin if the paragraph "NA" not applicable, "C" complies or "E" exception. Explain fully any exceptions to the paragraphs. Shop drawings and product data will not be reviewed with out submitting the specification compliance review.
- G. The contractor shall review and stamp submittals prior to submitting to the Engineer. Contractor shall identify any deviations from the bid documents in the submittal.
- H. Submittal will be reviewed for design conformity and general conformance to the Contract Documents only. Contractor is responsible for confirming and correlating dimensions at the job site for tolerances, clearances, quantities, fabrication processes and techniques of construction, coordination of the work with other trades and full compliance with the Contract Document.
- I. The contractor is responsible for submitting dimensioned layouts of electrical equipment locations within electrical rooms, generator rooms, and fire pump rooms, with equipment drawn to scale and identified therein. Working clearance and access shall be clearly identified on the drawings. Rooms shall be designed, including door openings, and clearance shall be provided to allow for the future removal of each generator, unit substation transformer, or other large piece of equipment independently without having to remove non-related equipment first.
- J. The contractors shall coordinate to provide at least one path to outside with 8'-0" tall door in main electrical rooms and generator rooms that contain switchgear, motor control centers, generators, and other equipment taller than 6'-6".
- K. Review submittals for conformance with the Contract Documents prior to submitting as specified in division 01.
 - 1. Submit complete information concerning changes in the project required by the submitted products. Include dimensional layouts, required MEP connections, clearances required for

- service and maintenance, weight, and other required information to insure the submitted equipment can be properly installed and operated in accordance with the Contract Documents.
- 2. Clearly identify changes required to other building systems. Submitting contractor shall be responsible for coordinating revisions with other trades and any additional compensation to other trades. Submitted equipment shall not result in an increase to the contract costs.
- L. Electronic copies of the Contract Documents may be obtained to use in preparing submittals for this project. A waiver provided by the Engineer shall be signed prior to the issuing of the files by the engineer.
- M. The Contract Documents are not to be considered of adequate detail to be submitted as a shop drawing.
- N. Provide a minimum of 8 hours of owner training.

1.16 PROJECT CLOSEOUT

- A. Closeout Procedure, Project record document, operation and maintenance data, shall be in accordance with Division 01 and as hereinafter specified.
- B. Provide a typed Installer's information list including the general contractor and any sub-contractors who performed part of the electrical system installation. Locate list at the front of the manual. Information for each contractor shall include:
 - 1. Name of Company
 - 2. Company address
 - 3. Company phone number and email address
 - 4. Contact person in company with their respective phone number and email address
- C. Electrical portion of the Operation and Maintenance data shall include;
 - 1. Installer's information list.
 - 2. Equipment and specialties furnished under Division 26 shall have the following grouped together in accordance with Division 01.
 - a. A clean copy of shop drawings marked definitively and legibly indicating equipment with provided options.
 - b. Manufacturer's installation, operation, & maintenance, instruction manuals.
 - c. Manufacturer's parts list if not included in the installation, operation, and maintenance manuals.
 - d. Manufacturer's recommended maintenance clearances if not included in the submitted manuals.
 - e. Any other manufacturer's printed data that would assist the owner in operating, maintaining or modifying the installed system in the future.
 - f. Copy of warranties

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS FOR MATERIAL AND EQUIPMENT

- A. All acceptable manufacturers listed for each item are completely subject to all requirements listed in the Electrical documents for that item.
- B. Basis of Design manufacturers and model numbers used in the Electrical Documents establish the type and basic quality required. Products shall be provided with:
 - 1. Standard devices/accessories/features as indicated in the latest edition of the manufacturer's catalog/brochure/website published at the date of the Bid.
 - 2. Any options or modifications as stated in the Electrical Documents.
 - 3. As required or modification for its proper installation or obvious intended use.
- C. Electrical components shall comply with the following:
 - 1. Manufactured by a company in the everyday business of producing that item.
 - 2. New (not previously used or re-manufactured), of the best quality, and free from defects.
- D. Equipment provided for the Project shall meet or exceed minimum values and shall not exceed maximum values indicated in the Electrical Documents.

- E. Equipment and systems shall be coordinated with other associated equipment and systems.

2.02 MATERIALS AND EQUIPMENT FURNISHED BY OTHERS

- A. When materials and equipment are indicated as furnished by others and installed or connected under this contract, it shall be the Contractor's responsibility to verify installation details and requirements and provide connection and assessors required for proper installation.

2.03 SLEEVES

- A. Interior sleeves Steel Pipe, ASTM A53, Type E Grade B, Schedule 40, galvanized with plain square ends and deburred.
- B. Sleeves in building envelope: Modular design, with interlocking rubber links, metal plates, and fasteners to for a continuous compressible rubber seal with in the annular space between the pipe and sleeve. Fasteners and plates shall be stainless steel.

2.04 CONCRETE BASES

- A. Bases shall be constructed of concrete with a 28 day compressive strength of 3000 psi.
- B. Interior bases shall be 3.5 inches above surrounding floor finish.
- C. Exterior bases shall be 5.5 inches above surrounding grade unless noted otherwise.
- D. Provide 6 x 6 10/10 welded wire fabric located in the center of each base unless noted or required otherwise.

2.05 EXCAVATION AND BACKFILL

- A. Provide clean backfill free of rocks and debris. Compact backfill in layers of not more than 6".
- B. Restore project site to original condition or as indicated on civil drawings.

2.06 SUSTAINABILITY REQUIREMENTS

- A. For field applications of adhesives, mastics, paint, or other material that are in the interior of the building, the VOC content cannot be greater than the requirements specified in Division 01 - Sustainable Design Requirements section(s).
- B.

PART 3 EXECUTION

3.01 GENERAL

- A. Fabrication, erection, and installation of the complete electrical system shall be done by qualified personnel, experienced in such work and shall proceed in an orderly manner so as not to hold up the progress of the object.
- B. Check areas and surfaces where electrical equipment or materials are to be installed and report any unsatisfactory conditions before starting work.
- C. Commencement of work signifies the Contractor's acceptance of the conditions as fit and proper for the execution of the electrical work.
- D. Install equipment and systems in accordance with manufacturer's instructions, requirements, or recommendations.
- E. Comply with NECA 1.
- F. Unless otherwise noted, measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- G. 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.
- H. 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 wit minimum interference with other items in the vicinity.
- I. Right of Way: Give right of way to piping systems requiring slope.

- J. Materials and Components: Install level, plumb, parallel, and perpendicular to building elements.
- K. Maintain equipment and pay all costs of operation, demonstration, tests and instruction until acceptance by owner.
- L. Notify the Architect as specified in Division 1 before proceeding with the work if a conflict arises between the work under this Section and other work.
- M. Do not proceed with the installation until unacceptable conditions are corrected.
- N. Conduits and cables cannot be installed through any solid structural component unless approved in writing by the Architect and Structural Consultant prior to the installation. Conduit and cables may be routed thru the open web of steel/wood bar-joists or trusses.
- O. Installation of conduit and cabling shall conform to the following requirements.
 - 1. Cannot block maintenance or service access to HVAC components or any other building system component or equipment.
 - 2. Allow sufficient space for ceiling panel removal above lay-in ceilings.

3.02 DELIVERY AND STORAGE OF MATERIALS

- A. Make provisions for the delivery and safe storage of materials. Make the required arrangements with other contractors for the introduction into the building of equipment too large to pass through finished openings.
- B. Materials shall be delivered at such stages of the work as will expedite the work as a whole and shall be marked and stored in such a way as to be easily checked and inspected.
- C. Adequately protect supplies and equipment during cold weather.
- D. Protect items subject to cold weather damage by covering, insulating, or storing in a heated space.
- E. Off load poles and other items which may be damaged by chains or cables with appropriate hoisting materials. Protect items so not to damage during offloading.
- F. While temporarily storing Electrical components, do not exceed the structural capacity of the floor.
- G. Items intended for indoor installation cannot be stored exposed to outdoor weather conditions.
- H. Any Electrical component that can be damaged by water shall be protected from direct contact with rain, sprayed water, runoff, standing water, or any other type of moisture that will soak into or corrode the component. Items that have absorbed water or have been prematurely corroded cannot be utilized on the Project.
- I. Any Electrical component that can be damaged by direct sunlight shall be protected.
- J. Maintain any factory-applied protective coatings during construction until removal is required for system testing or final cleaning.
- K. Any Electrical component that has been damaged during delivery, storage, or construction before final acceptance by the Owner shall be repaired or replaced to return the item to a "like new" condition in a manner approved by the Engineer.
 - 1. Repair: This method may be used if an electrical item can be repaired by field correcting or replacing the damaged component of that item without affecting the item's warranty, service life, construction integrity, or visual appearance. all work shall be done in strict accordance with the manufacturer's instructions, requirements, and/or supervision.
 - 2. Replace: This method shall be used if, in the Engineer's opinion, the damage is too great to warrant a simple repair, the appearance of the item cannot be returned to a state where the original damage cannot be detected, or if the damage/repair voids any portion of the items warranty.

3.03 COORDINATION OF WORK

- A. Plan work so it proceeds with a minimum of interference with other trades.

- B. Inform the General Contractor of all openings required in the building construction for the installation of the electrical work.
- C. Cooperate with other contractors in furnishing material and information, in proper sequence, for the correct location of sleeves, inserts, foundations, wiring, etc.
- D. Make provisions for special frames, openings, and sleeves as required.
- E. The Electrical Contractor shall pay for extra cutting and patching made necessary by his failure to properly direct such work at the correct time.

3.04 UTILITY COORDINATION

- A. Become familiar with the utility's requirements, regulations, standard drawings and specifications.
- B. Field verify the installation with the utility's representative prior to rough-in.
- C. Field verify the location of the transformer, CT cabinet, and meters with the utility. Proposed locations indicated on the plans are for reference only and final locations shall be determined on site by the utility company. Inform the engineer immediately of any changes.
- D. Submit electrical drawings and service application to electric utility company prior to starting any work and obtaining in writing approval from the local utility indicating that the service design is acceptable. Provide a copy of the written approval for the engineer.

3.05 LAYOUT OF WORK

- A. Carefully lay out work in advance of installation using data and measurements from the site, the appropriate architectural and structural drawings, and shop drawings.
- B. Confirm code required clearances.
- C. Do not infringe upon space required for operation, maintenance, or clearance for items installed by other contractors.
- D. Prior to installation of any work, make certain the location does not conflict with other items in or near the same location.
- E. If the layouts so prepared indicate that the required conditions cannot be met in the space provided, inform the Architect/Engineer prior to installation and request clarification.
- F. Failure to properly coordinate and lay out work will require correction by the Contractor at the Contractor's expense.

3.06 DATA AND MEASUREMENTS

- A. Mechanical and electrical drawings are diagrammatic or schematic. Do not scale drawings.
- B. The data given herein and on the drawings is as accurate as could be secured; absolute accuracy is not guaranteed.
- C. Obtain exact locations, measurements, levels, etc., at the site and adapt their work to actual conditions.
- D. Examine the general construction, mechanical, electrical, and other applicable drawings and the Specifications.
- E. Utilize only architectural drawings, structural drawings, and site measurements in calculations.
- F. Layout and coordinate work prior to installation to provide clearances for operation, maintenance and codes. Verify non-interference with other work.
- G. Locate outlets and devices mounted on finished surfaces with regard to paneling, furring, trim, etc.
- H. Install outlets and devices with vertical edges of plates plumb.
- I. Install boxes or plaster rings such that the front edge extends to the finished surface of the wall, ceiling or floor without projecting beyond the surface.
- J. Install receptacles, switches, etc., on wood trim, cases, or other fixtures symmetrically and, where necessary, install with the long dimension of the plate horizontal.

- K. Coordinate locations of outlets and devices with other contractors so as not to destroy the aesthetic effect of the surface in which the outlets and devices are mounted. Coordinate the locations of electrical items with work furnished by other trades to avoid interference.
- L. Heights of outlets are measured from finished floor to centerline of device.
- M. Adjust heights as necessary to clear wall-mounted cabinets, fin tube convectors, unit heaters, etc.
- N. Mounting heights shall be in compliance with ADA requirements.
- O. When devices are installed in masonry walls, adjust mounting heights to correspond to block coursing. Do not mount outlets below 15 inches or switches above 46 inches.
- P. Within 60 days of substantial completion, perform an infrared scan of each termination and splice in conductors #3 AWG and larger. Infrared scan reports shall be provided to HCA Engineering.
- Q. Balance circuits so that feeders to panels are not more than 10% out of balance between phases with all available load energized and operating. All ampere readings should be made with a true RMS reading meter.
- R. Perform megger tests of all feeders and provide a report of results including values measured.
- S. Project close out manuals shall include copies of the following test results/certifications:
 - 1. Service ground resistance test.
 - 2. Switchboard/panelboard ampere readings, including all major circuit breakers.
 - 3. Generator test.
 - 4. Ground fault test.
 - 5. Patient care area grounding test (leakage current for fixed equipment including beds).
 - 6. Fire alarm certification.
 - 7. Nurse call certification.
 - 8. Lightning protection certification.

3.07 PROTECTION OF APPARATUS

- A. Take necessary precautions to properly protect apparatus, fixtures, appliances, material, equipment, and installations from damage.
- B. Failure to provide such protection to the satisfaction of the Architect/Engineer shall be sufficient cause for the rejection of any particular piece(s) of material, apparatus, equipment, etc., concerned.

3.08 SLEEVE INSTALLATION

- A. Coordinate sleeve selection and application with selection of and application of fireproofing.
- B. Concrete Slabs and walls: Install sleeves during erection of slabs and walls. Sleeves are not required for core drilled holes.
- C. Sleeves thru walls shall be flush on both sides.
- D. Sleeves thru floors shall extend 2 inches above finished floor.
- E. Sleeves thru roofs shall be sealed with boot type flashing and coordinated with roofing materials.

3.09 FIRE STOPPING

- 1. Apply fire stopping to electrical penetrations of fire-rated floor and wall assemblies to maintain fire resistance rating of the assembly.
- 2. Where walls are installed above ceilings; Seal all penetrations in walls made by electrical items.

3.10 EXCAVATION

- A. Perform excavation of every description and of whatever substances encountered, to the depths required or indicated on the drawings, in accordance with OSHA.

- B. During excavation, deposit material suitable for backfill in an orderly manner a sufficient distance from the excavation banks to avoid overloading and to prevent slides or cave-ins.
- C. Dispose of material unsuitable for backfill as directed by the Architect/Engineer.
- D. Grade as necessary to prevent surface water from flowing into trenches or other excavations, and remove any water accumulating therein by pumping or by other acceptable method.
- E. Fill any excess excavation below the levels indicated for structures or raceways with sand, gravel or concrete.
 - 1. Unsuitable Materials.
 - 2. Where the bottom of the trench is found to be unstable or to include ashes, cinders, any types of refuse, vegetable or other organic material, or large pieces or fragments of inorganic material, which in the judgment of the Architect/Engineer should be removed, excavate and remove such unsuitable material to a minimum depth of 12 inches below the conduit.
 - 3. Backfill the trench with selected bedding material and compact to provide uniform and continuous bearing for the conduit.
 - 4. Dispose of the unsuitable material.

3.11 BACKFILL

- A. Do not backfill until required inspections are made and tests are performed for the specific utility.
- B. Backfill with the excavated materials specified for back filling, consisting of earth, loam, sandy clay, sand and gravel or other materials, free from large clods of earth or stones.
- C. Do not use broken concrete as backfill materials.
- D. Do not backfill in freezing weather or with frozen material.
- E. Adjust the moisture content of the backfill material if required for proper compaction.
- F. Reopen any trenches improperly back filled, or where settlement occurs, to the depth required for proper compaction, refill and compact to specified density.
- G. Compact backfill for structures to the specified density.
- H. During the back filling of each exterior underground conduit system, install continuous underground type plastic line markers.
- I. Deposit suitable backfill material around the conduit in 6-inch layers and thoroughly compact by hand, machine tamper, or other suitable equipment.
- J. Backfill to at least 90 percent of maximum density at optimum moisture content determined by ASTM D698 until the conduit has a minimum cover of 2 feet.
- K. The moisture content of the soil at time of compaction shall be not more than 3 percent above or 3 percent below the optimum.
- L. Be careful not to disturb the conduit.
- M. Carry back filling on simultaneously on both sides of the conduit to eliminate the possibility of lateral displacement.
- N. Prepare back filled areas to receive seeding.

3.12 TEMPORARY POWER AND LIGHTING

- A. Provide temporary power and lighting throughout the construction period for the use by all trades, contractors and sub-contractors.
- B. Temporary facilities shall be installed in compliance with applicable codes and in compliance with OSHA requirements.
- C. Cost of temporary power used during construction, including the cost of setting and removing temporary service, shall be paid by the contractor.

3.13 SUSTAINABILITY REQUIREMENT

- A. Perform all work in a manner as required in Division 1.

3.14 DAMAGE AND TOUCH-UP PAINTING

- A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures as provided by the equipment manufacturer to match the original factory finish and in a manner/appearance acceptable to the Architect.

3.15 PROTECTION AND CLEANING

- A. Keep areas clear of debris during construction. Promptly remove waste material from premises.
- B. Clean all exposed Electrical Equipment in finished and unfinished areas.
- C. Thoroughly clean both the accessible inside and the entire outside of all equipment.
- D. Take measures to protect completed areas and/or existing areas of the building from the migration of construction-generated contaminants.

END OF SECTION

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SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single conductor building wire.
- B. Wiring connectors.
- C. Electrical tape.
- D. Heat shrink tubing.
- E. Oxide inhibiting compound.
- F. Wire pulling lubricant.

1.02 REFERENCE STANDARDS

- A. ASTM B800 - Standard Specification for 8000 Series Aluminum Alloy Wire for Electrical Purposes - Annealed and Intermediate Tempers 2005 (Reapproved 2021).
- B. ASTM B801 - Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation 2018.
- C. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape 2017.
- D. NECA 104 - Standard for Installing Aluminum Building Wire and Cable 2012.
- E. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy 2021.
- F. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- G. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 44 - Thermoset-Insulated Wires and Cables Current Edition, Including All Revisions.
- I. UL 83 - Thermoplastic-Insulated Wires and Cables Current Edition, Including All Revisions.
- J. UL 486A-486B - Wire Connectors Current Edition, Including All Revisions.
- K. UL 486C - Splicing Wire Connectors Current Edition, Including All Revisions.
- L. UL 486D - Sealed Wire Connector Systems Current Edition, Including All Revisions.
- M. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
 - 3. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 CONDUCTOR AND CABLE APPLICATIONS

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.
- C. Nonmetallic-sheathed cable is not permitted.
- D. Armored cable is not permitted.

2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductors for Grounding and Bonding: Also comply with Section 26 05 26.
- H. Conductor Material:
 - 1. Provide copper conductors except where aluminum conductors are specifically indicated or permitted for substitution. Conductor sizes indicated are based on copper unless specifically indicated as aluminum.
 - a. Branch circuit wiring shall be copper.
 - b. Service and feeder wiring under 200 amps shall be copper.
 - c. Substitution of aluminum conductors for copper is permitted, when approved by Owner and authority having jurisdiction, only for the following:
 - 1) Normal power service and feeder wiring 200 amps and over shall be designed as aluminum alloy unless prohibited below. Contractor may substitute copper at no additional cost.
 - 2) Exceptions:
 - (a) All feeders connecting directly to motors, including, but not limited to, chillers and fire pumps, shall be copper to minimize loosening of connectors due to cyclical thermal expansion.
 - (b) All essential power systems circuits shall be copper.
 - d. Where aluminum conductors are substituted for copper, comply with the following:
 - 1) Size aluminum conductors to provide, when compared to copper sizes indicated, equivalent or greater ampacity and equivalent or less voltage drop.
 - 2) Increase size of raceways, boxes, wiring gutters, enclosures, etc. as required to accommodate aluminum conductors.
 - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
 - 3. Tinned Copper Conductors: Comply with ASTM B33.
 - 4. Aluminum Conductors (only where specifically indicated or permitted for substitution): AA-8000 series aluminum alloy conductors recognized by ASTM B800 and compact stranded in accordance with ASTM B801 unless otherwise indicated. Stabiloy or Southwire brands shall be used.
- I. Conductor Color Coding:
 - 1. Color Coding Method: Integrally colored insulation.
 - a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
 - 2. Color Code:
 - a. 480Y/277 V, 3 Phase, 4 Wire System:

- 1) Phase A: Brown.
- 2) Phase B: Orange.
- 3) Phase C: Yellow.
- 4) Neutral/Grounded: Gray.
- b. 208Y/120 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral/Grounded: White.
- c. Equipment Ground, All Systems: Green.
- d. For modifications or additions to existing wiring systems, comply with existing color code when existing code complies with NFPA 70 and is approved by the authority having jurisdiction.

2.03 SINGLE CONDUCTOR BUILDING WIRE

- A. Description: Single conductor insulated wire.
- B. Conductor Stranding:
 1. Feeders and Branch Circuits:
 - a. Size 12 AWG and Smaller: Solid.
 - b. Size 10 AWG and Larger: Stranded.
- C. Insulation Voltage Rating: 600 V.
- D. Insulation:
 1. Copper Building Wire: Type THHN/THWN-2, except as indicated below.
 - a. Installed Underground: Type XHHW-2.

2.04 WIRING CONNECTORS

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.
- B. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- C. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.
- D. Twist-on Insulated Spring Connectors: Rated 600 V, 221 degrees F for standard applications and 302 degrees F for high temperature applications; pre-filled with sealant and listed as complying with UL 486D for damp and wet locations.

2.05 ACCESSORIES

- A. Electrical Tape:
 1. Vinyl Color Coding Electrical Tape: Integrally colored to match color code indicated; listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; suitable for continuous temperature environment up to 221 degrees F.
 2. Vinyl Insulating Electrical Tape: Complying with ASTM D3005 and listed as complying with UL 510; minimum thickness of 7 mil; resistant to abrasion, corrosion, and sunlight; conformable for application down to 0 degrees F and suitable for continuous temperature environment up to 221 degrees F.
- B. Heat Shrink Tubing: Heavy-wall, split-resistant, with factory-applied adhesive; rated 600 V; suitable for direct burial applications; listed as complying with UL 486D.
- C. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.
- D. Wire Pulling Lubricant: Listed; suitable for use with the conductors or cables to be installed and suitable for use at the installation temperature.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that interior of building has been protected from weather.
- B. Verify that work likely to damage wire and cable has been completed.
- C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- D. Verify that field measurements are as indicated.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.03 INSTALLATION

- A. Circuiting Requirements:
 - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
 - 2. When circuit destination is indicated without specific routing, determine exact routing required.
 - 3. Arrange circuiting to minimize splices.
 - 4. Provide #10 conductors for 120V 15 and 20 amp branch circuits over 75'.
 - 5. Provide #10 conductors for 277V 15 and 20 amp branch circuits over 150'.
 - 6. verify each feeder circuit will not exceed 2% voltage drop as field installed. Provide larger conductors/conduit as required to maintain 2% voltage drop for load served.
 - 7. verify each branch circuit will not exceed 3% voltage drop as field installed. Provide larger conductors/conduit as required to maintain 3% voltage drop for load served.
- B. Provide no more than six current-carrying conductors in a single raceway. Dedicated neutral conductors are considered current-carrying conductors.
 - 1. Increase size of conductors as required to account for ampacity derating.
- C. Install products in accordance with manufacturer's instructions.
- D. Perform work in accordance with NECA 1 (general workmanship).
- E. Install aluminum conductors in accordance with NECA 104.
- F. Installation in Raceway:
 - 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
 - 2. Pull all conductors and cables together into raceway at same time.
 - 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 - 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- G. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- H. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
 - 1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
 - 2. Installation in Vertical Raceways: Provide supports where vertical rise exceeds permissible limits.
- I. Install conductors with a minimum of 6 inches of slack at each outlet.
- J. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

- K. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- L. Make wiring connections using specified wiring connectors.
 - 1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
 - 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
 - 3. Do not remove conductor strands to facilitate insertion into connector.
 - 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminants. Do not use wire brush on plated connector surfaces.
 - 5. Connections for Aluminum Conductors: Fill connectors with oxide inhibiting compound where not pre-filled by manufacturer.
- M. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
- N. Insulate ends of spare conductors using vinyl insulating electrical tape.
- O. Provide an insulated ground conductor in each line voltage circuit
- P. Provide a dedicated neutral for each circuit requiring a neutral conductor.
- Q. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- R. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- S. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.
- T. Low voltage, e.g. communications wiring, when not required to be in conduit, shall be plenum rated where used in air plenums.
- U. Low voltage wiring not routed in a race way shall be supported by cable tray or j-hooks secured independently of ceiling supports. Cabling shall not be supported directly by the ceiling system.
- V. Branch circuits concealed in ceilings, walls, and partitions: Type THHN-THWN, single conductors in raceway and Type HCF in limited locations where indicated. Type HCF is acceptable for the following applications.
 - 1. Feeders for lighting fixture whips and for branch circuits concealed in walls and partitions only. Locate junction box and convert to single conductors in rigid raceway within the same room as where the cable enters/exits the wall.
 - 2. Use only for single-circuit cable (i.e. two wire plus ground). For devices in the same wall connected to different circuits, install separate single circuit cable for each circuit.
 - 3. The HCF length for power circuits shall be limited to 30' from the junction box to the wiring device located in the wall. If the circuit continues outside the wall, the circuit must immediately transition to conduit.
 - 4. The HCF length for lighting circuits shall be limited to 30' from the junction box to the first fixture and from that point only those fixtures above the enclosed space/room shall be served by this HCF circuit.
- W. Type HCF is not acceptable for the following applications; instead provide single conductors in non-flexible raceway.
 - 1. Homeruns to panelboards.
 - 2. Branch circuits serving Essential Electrical System loads; including Life Safety branch, Critical branch, and Equipment branch systems.
 - 3. Branch circuits serving HVAC, elevator/escalator, medical, and kitchen equipment loads.
 - 4. Within mechanical, electrical, or telecommunications equipment rooms.
 - 5. Exposed branch circuits within areas that do not have a ceiling (i.e. open to structure).
 - 6. Wet locations.

3.04 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is only required for services and feeders. The resistance test for parallel conductors listed as optional is not required.
- D. Correct deficiencies and replace damaged or defective conductors and cables.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.
- F. Ground access wells.
- G. Concrete encased electrodes.

1.02 REFERENCE STANDARDS

- A. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- B. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify exact locations of underground metal water service pipe entrances to building.
 - 2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
- B. Sequencing:
 - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 GROUNDING AND BONDING REQUIREMENTS

- A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- D. Grounding Electrode System:
 - 1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
 - a. Provide continuous grounding electrode conductors without splice or joint.
 - b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with

- bonding jumper.
- 2. Metal Underground Water Pipe(s):
 - a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
 - b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
 - c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
- 3. Concrete-Encased Electrode:
 - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
- 4. Ground Rod Electrode(s):
 - a. Provide single electrode unless otherwise indicated or required.
 - b. Space electrodes not less than 10 feet from each other and any other ground electrode.
 - c. Where location is not indicated, locate electrode(s) at least 5 feet outside building perimeter foundation as near as possible to electrical service entrance; where possible, locate in softscape (uncovered) area.
- 5. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in NFPA 70. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
 - a. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
 - b. Where ground bar location is not indicated, locate in accessible location as near as possible to service disconnect enclosure.
 - c. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.
- 6. Where a facility ground loop is provided for the lightning protection system, the service shall be bonded to the ground loop.
 - a. New facilities shall have a ground grid (loop) installed around the building with the ground bonded to each corner column and every other column from the corner column.
- E. Separately Derived System Grounding:
 - 1. Separately derived systems include, but are not limited to:
 - a. Transformers (except autotransformers such as buck-boost transformers).
 - b. Uninterruptible power supplies (UPS), when configured as separately derived systems.
 - c. Generators, when neutral is switched in the transfer switch.
 - 2. Provide grounding electrode conductor to connect derived system grounded conductor to nearest effectively grounded metal building frame. Unless otherwise indicated, make connection at neutral (grounded) bus in source enclosure.
 - 3. Provide bonding jumper to connect derived system grounded conductor to nearest metal building frame and nearest metal water piping in the area served by the derived system, where not already used as a grounding electrode for the derived system. Make connection at same location as grounding electrode conductor connection.
 - 4. Where common grounding electrode conductor ground riser is used for tap connections to multiple separately derived systems, provide bonding jumper to connect the metal building frame and metal water piping in the area served by the derived system to the common grounding electrode conductor.
 - 5. Provide system bonding jumper to connect system grounded conductor to equipment ground bus. Make connection at same location as grounding electrode conductor connection. Do not make any other connections between neutral (grounded) conductors and ground on load side of separately derived system disconnect.

6. Where the source and first disconnecting means are in separate enclosures, provide supply-side bonding jumper between source and first disconnecting means.
- F. Bonding and Equipment Grounding:
1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
 2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
 3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
 4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
 5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
 6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.

2.02 GROUNDING AND BONDING COMPONENTS

- A. General Requirements:
1. Provide products listed, classified, and labeled as suitable for the purpose intended.
 2. Provide products listed and labeled as complying with UL 467 where applicable.
- B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 05 26:
1. Use insulated copper conductors unless otherwise indicated.
 - a. Exceptions:
 - 1) Use bare copper conductors where installed underground in direct contact with earth.
 - 2) Use bare copper conductors where directly encased in concrete (not in raceway).
- C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
 2. Unless otherwise indicated, use compression connectors for underground, concealed and other inaccessible connections.
 - a. Exceptions:
 - 1) Use mechanical connectors for connections to electrodes at ground access wells.
 3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.
- D. Ground Bars:
1. Description: Copper rectangular ground bars with mounting brackets and insulators.
 2. Size: As indicated.
 3. Holes for Connections: As indicated or as required for connections to be made.
- E. Ground Rod Electrodes:
1. Comply with NEMA GR 1.
 2. Material: Copper-bonded (copper-clad) steel.
 3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.
- F. Ground Access Wells:
1. Description: Open bottom round or rectangular well with access cover for testing and inspection; suitable for the expected load at the installed location.
 2. Size: As required to provide adequate access for testing and inspection, but not less than minimum size requirements specified.
 - a. Round Wells: Not less than 8 inches in diameter.

3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 10 inches.
4. Cover: Factory-identified by permanent means with word "GROUND".

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or provide ground plates.
 1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches below finished grade.
- D. Make grounding and bonding connections using specified connectors.
 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- E. Identify grounding and bonding system components in accordance with Section 26 05 53.

3.03 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.13.
- C. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- D. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.

END OF SECTION

**SECTION 26 05 29
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.02 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 2016a.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel 2023.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00.

1.04 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with applicable building code.

1.05 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of 1.25. Include consideration for vibration, equipment operation, and shock loads where applicable.
 - 4. Do not use products for applications other than as permitted by NFPA 70 and product listing.

5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. 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.
6. J-hooks shall be used for communication and other low voltage wiring not in conduit.
- B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.
- D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 1. Comply with MFMA-4.
 2. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
 3. Manufacturers:
 - a. Source Limitations: Furnish channels (struts) and associated fittings, accessories, and hardware produced by a single manufacturer.
- E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
- F. Non-Penetrating Rooftop Supports for Low-Slope Roofs: Steel pedestals with thermoplastic or rubber 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.
 1. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 2. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
 3. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
- G. Anchors and Fasteners:
 1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
 2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
 3. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
 4. Hollow Masonry: Use toggle bolts.
 5. Hollow Stud Walls: Use toggle bolts.
 6. Steel: Use beam clamps, machine bolts, or welded threaded studs.
 7. Sheet Metal: Use sheet metal screws.
 8. Wood: Use wood screws.
 9. Plastic and lead anchors are not permitted.
 10. Powder-actuated fasteners are permitted only as follows:
 - a. Where approved by Architect/structural engineer.
 11. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.

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

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- E. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- F. Equipment Support and Attachment:
 - 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 4 inch high concrete pad constructed in accordance with Section 03 30 00.
 - 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- G. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- H. Secure fasteners according to manufacturer's recommended torque settings.
- I. Remove temporary supports.
- J. Identify independent electrical component support wires above accessible ceilings (only where specifically indicated or permitted) with color distinguishable from ceiling support wires in accordance with NFPA 70.

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

END OF SECTION

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**SECTION 26 05 33.13
CONDUIT FOR ELECTRICAL SYSTEMS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Intermediate metal conduit (IMC).
- C. Flexible metal conduit (FMC).
- D. Liquidtight flexible metal conduit (LFMC).
- E. Electrical metallic tubing (EMT).
- F. Rigid polyvinyl chloride (PVC) conduit.
- G. Conduit fittings.
- H. Accessories.

1.02 REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC) 2020.
- B. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.
- C. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing 2021.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 6 - Electrical Rigid Metal Conduit-Steel Current Edition, Including All Revisions.
- F. UL 514B - Conduit, Tubing, and Cable Fittings Current Edition, Including All Revisions.
- G. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
 - 4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
- B. Sequencing:
 - 1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

1.04 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70 and product listing.

- B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
 - 1. Under Slab on Grade: Use intermediate metal conduit (IMC) or rigid PVC conduit.
 - 2. Exterior, Direct-Buried: Use intermediate metallic conduit (IMC) or Schedule 80 PVC.
 - 3. Exterior, Embedded Within Concrete: Use rigid PVC conduit.
- D. Embedded Within Concrete:
 - 1. Within Slab on Grade (within structural slabs only where approved by Structural Engineer): Use rigid PVC conduit.
 - 2. Within Slab Above Ground (within structural slabs only where approved by Structural Engineer): Use galvanized steel rigid metal conduit or rigid PVC conduit.
 - 3. Within Concrete Walls Above Ground: Use galvanized steel rigid metal conduit or rigid PVC conduit.
- E. Concealed Within Masonry Walls: Use galvanized steel rigid metal conduit or electrical metallic tubing (EMT).
- F. Concealed Within Hollow Stud Walls: Use electrical metallic tubing (EMT).
- G. Concealed Above Accessible Ceilings: Use electrical metallic tubing (EMT).
- H. Interior, Damp or Wet Locations: Use intermediate metal conduit (IMC) or electrical metallic tubing (EMT).
- I. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel rigid metal conduit, intermediate metal conduit (IMC), or electrical metallic tubing (EMT).
- J. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
 - 1. Locations subject to physical damage include, but are not limited to:
 - a. Where exposed below 8 feet, with in mechanical room, docks, and warehouses.
- K. Exposed, Exterior: Use galvanized steel rigid metal conduit or intermediate metal conduit (IMC).
- L. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use intermediate metal conduit (IMC) or electrical metallic tubing (EMT).
- M. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
 - 1. Maximum Length: 6 feet.
- N. Connections to Vibrating Equipment:
 - 1. Dry Locations: Use liquidtight flexible metal conduit.
 - 2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
 - 3. Maximum Length: 6 feet unless otherwise indicated.
- O. Fished in Existing Walls, Where Necessary: Use flexible metal conduit.

2.02 CONDUIT REQUIREMENTS

- A. Existing Work: Where existing conduits are indicated to be reused, they may be reused only where they comply with specified requirements, are free from corrosion, and integrity is verified by pulling a mandrel through them.
- B. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Minimum Conduit Size, Unless Otherwise Indicated:
 - 1. Branch Circuits: 1/2 inch (16 mm) trade size.
 - 2. Underground, Interior: 3/4 inch (21 mm) trade size.
 - 3. Underground, Exterior: 3/4 inch (21 mm) trade size.

- E. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- F. Conduit and raceways are to be color coded for ease of identification. Provide color-coding in accordance with HCA conduit color table

Conduit Service:	Color Description:
Building Automation & Controls	Blue
Fire Alarm	Red
Life Safety Power Branch	Yellow
Critical Power Branch	Orange
Equipment Power Branch	Green
Emergency Power Distribution Not Listed Above	Purple

- G. As the HCA standard, conduit is to be color-coded from the factory. Junction boxes, fittings, and connectors are not required to be painted to match.
- H. As an alternative, contractor may submit a deduct to omit use of factory-painted conduit. If accepted, tape or paint are to be used to identify conduits and junction boxes and/or fittings are to be painted in accordance with the facility standard or color table.

2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- 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. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.
 - 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.04 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. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - a. Do not use die cast zinc fittings.
 - 3. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.05 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 to be used.
- 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.
 - a. Do not use die cast zinc fittings.

2.06 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.
 - a. Do not use die cast zinc fittings.

2.07 ELECTRICAL METALLIC TUBING (EMT)

- A. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- 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.
 - a. Do not use die cast zinc fittings.
 3. Connectors and Couplings: Use set-screw type.
 - a. Do not use indenter type connectors and couplings.

2.08 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; rated for use with conductors rated 90 degrees C.
- 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.

2.09 ACCESSORIES

- A. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- B. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.
- C. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install intermediate metal conduit (IMC) in accordance with NECA 101.
- E. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- F. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 1. Above Ground: RMC or IMC
 2. Within Crawl Spaces: RMC or IMC
 3. Emergency Feeders: RMC or IMC
 4. Connection to vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment): LFMC
- G. Comply with the following indoor applications, unless otherwise indicated:
 1. Exposed, not subject to physical damage: EMT

2. Exposed and subject to physical damage: RMC or IMC
 3. Conductors over 600 volts: RMC or IMC
 4. Concealed in ceilings and interior walls and partitions: EMT
 5. Concealed in masonry walls: RMC or IMC
 6. Concealed under raised floors: EMT or LFMC
 7. Connection to vibrating equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor-driven equipment): FMC, except use LFMC in damp or wet locations
 8. Flexible connection to luminaires: FMC, maximum of 72 inches
 9. Damp or Wet locations: RMC or IMC
 10. Elevator pits: RMC, IMC, or LFMC
 11. Emergency feeders and branch circuits: EMT
 12. Corrosive locations: PVC-coated RMC, or PVC-coated steel conduit
- H. Provide minimum 1/2" conduit for controls circuiting.
- I. Use the shortest path possible to the intended load or receptacle for raceways of ungrounded circuits which are electrically monitored by ground detector system; this is intended to minimize leakage current to ground. In ceiling space, utilize paths that deviate from the perpendicular to structure where these paths will not interfere with other overhead systems.
- J. Conduit Routing:
1. Unless dimensioned, conduit routing indicated is diagrammatic.
 2. When conduit destination is indicated without specific routing, determine exact routing required.
 3. Conceal all conduits unless specifically indicated to be exposed.
 4. Conduits in the following areas may be exposed, unless otherwise indicated:
 - a. Electrical rooms.
 - b. Mechanical equipment rooms.
 - c. Within joists in areas with no ceiling.
 5. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
 6. Arrange conduit to maintain adequate headroom, clearances, and access.
 7. Arrange conduit to provide no more than the equivalent of four 90 degree bends between pull points.
 8. Arrange conduit to provide no more than 150 feet between pull points.
 9. Route conduits above water and drain piping where possible.
 10. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
 11. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
 12. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
 - a. Heaters.
 - b. Flues.
 13. Group parallel conduits in the same area together on a common rack.
 14. Flexible conduit of any type shall not exceed 6 feet in length.
- K. Conduit Support:
1. Secure and support conduits in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
 2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
 3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
 4. Use conduit strap to support single surface-mounted conduit.

- a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
5. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
- L. Connections and Terminations:
 1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
 2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
 3. Use suitable adapters where required to transition from one type of conduit to another.
 4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
 5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
 6. Where spare conduits stub up through concrete floors and are not terminated in a box or enclosure, provide threaded couplings equipped with threaded plugs set flush with finished floor.
 7. Secure joints and connections to provide maximum mechanical strength and electrical continuity.
- M. Penetrations:
 1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
 2. Make penetrations perpendicular to surfaces unless otherwise indicated.
 3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
 4. Conceal bends for conduit risers emerging above ground.
 5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
 6. Provide suitable modular seal where conduits penetrate exterior wall below grade.
 7. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
 8. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
 9. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00.
- N. Underground Installation:
 1. Minimum Cover, Unless Otherwise Indicated or Required:
 - a. Underground, Exterior: 24 inches.
 2. Provide underground warning tape in accordance with Section 26 05 53 along entire conduit length for service entrance where not concrete-encased.
- O. Embedment Within Structural Concrete Slabs (only where approved by Structural Engineer):
 1. Secure conduits to prevent floating or movement during pouring of concrete.
- P. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 03 30 00 with minimum concrete cover of 3 inches on all sides unless otherwise indicated.
- Q. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
 1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
 2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.

3. Where conduits are subject to earth movement by settlement or frost.
- R. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
 1. Where conduits pass from outdoors into conditioned interior spaces.
 2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
 3. Where conduits penetrate coolers or freezers.
- S. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Leave minimum slack of 12 inches at each end.
- T. Provide grounding and bonding in accordance with Section 26 05 26.
- U. Identify conduits in accordance with Section 26 05 53.

3.03 CLEANING

- A. Clean interior of conduits to remove moisture and foreign matter.

3.04 PROTECTION

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION

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SECTION 26 05 33.16
BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Underground boxes/enclosures.

1.02 REFERENCE STANDARDS

- A. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable 2014.
- B. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports 2013 (Reaffirmed 2020).
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 514A - Metallic Outlet Boxes Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
 - 4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
 - 5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
 - 6. Coordinate the work with other trades to preserve insulation integrity.
 - 7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 BOXES

- A. General Requirements:
 - 1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
 - 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
 - 3. Provide products listed, classified, and labeled as suitable for the purpose intended.

4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
 1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
 2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
 3. Use suitable concrete type boxes where flush-mounted in concrete.
 4. Use suitable masonry type boxes where flush-mounted in masonry walls.
 5. Use raised covers suitable for the type of wall construction and device configuration where required.
 6. Use shallow boxes where required by the type of wall construction.
 7. Do not use "through-wall" boxes designed for access from both sides of wall.
 8. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
 9. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
 10. Boxes for Supporting Luminaires and Ceiling Fans: Applicable to luminaires and fans weighing 70 pounds. Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
 11. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
 12. Minimum Box Size, Unless Otherwise Indicated:
 - a. Wiring Devices (Other Than Communications Systems Outlets): 4 inch square by 2-1/8 inch deep (100 by 54 mm) trade size.
 - b. Communications Systems Outlets: 4 inch square by 2-1/8 inch (100 by 54 mm) trade size.
 13. Wall Plates: Comply with Section 26 27 26.
- C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
 1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
 2. NEMA 250 Environment Type, Unless Otherwise Indicated:
 - a. Indoor Clean, Dry Locations: Type 1, painted steel.
 - b. Outdoor Locations: Type 3R, painted steel.
 - c. Commercial kitchens: Type 4 stainless steel
 - d. Institutional kitchens: Type 4 nonmetallic
 3. Junction and Pull Boxes Larger Than 100 cubic inches:
 - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
 4. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.
- D. Underground Boxes/Enclosures:
 1. Description: In-ground, open bottom boxes furnished with flush, non-skid covers with legend indicating type of service and stainless steel tamper resistant cover bolts.
 2. Size: as required by code..
 3. Applications:
 - a. Do not use polymer concrete enclosures in areas subject to deliberate vehicular traffic.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive boxes.

- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide separate boxes for emergency power and normal power systems.
- E. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- F. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- G. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- H. Box Locations:
1. Locate boxes to be accessible. Provide access panels as required where approved by the Architect.
 2. Unless dimensioned, box locations indicated are approximate.
 3. Locate boxes so that wall plates do not span different building finishes.
 4. Locate boxes so that wall plates do not cross masonry joints.
 5. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
 6. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.
 7. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.
 8. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
 - a. Do not install flush-mounted boxes with area larger than 16 square inches or such that the total aggregate area of openings exceeds 100 square inches for any 100 square feet of wall area.
 9. Locate junction and pull boxes as indicated, as required to facilitate installation of conductors, and to limit conduit length and/or number of bends between pulling points in accordance with Section 26 05 33.13.
- I. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 05 29 using suitable supports and methods approved by the authority having jurisdiction.
 2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
 3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
 4. Use far-side support to secure flush-mounted boxes supported from single stud in hollow stud walls. Repair or replace supports for boxes that permit excessive movement.
- J. Install boxes plumb and level.
- K. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
 2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.

3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.
- L. Install boxes as required to preserve insulation integrity.
- M. Underground Boxes/Enclosures:
 1. Install enclosure on gravel base, minimum 6 inches deep.
 2. Flush-mount enclosures located in concrete or paved areas.
 3. Install additional bracing inside enclosures in accordance with manufacturer's instructions to minimize box sidewall deflections during backfilling. Backfill with cover bolted in place.
- N. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- O. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in fireproofing Section.
- P. Close unused box openings.
- Q. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- R. Provide grounding and bonding in accordance with Section 26 05 26.
- S. Identify boxes in accordance with Section 26 05 53.

3.03 CLEANING

- A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

3.04 PROTECTION

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

END OF SECTION

SECTION 26 05 35
ELECTRICAL UNDERGROUND DUCTS, DUCTBANKS, AND MANHOLES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Conduit and duct:
 - 1. Rigid polyvinyl chloride (PVC) conduit.
 - 2. High density polyethylene (HDPE) conduit.
- B. Accessories:
 - 1. Underground warning tape.

1.02 REFERENCE STANDARDS

- A. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit 2020.
- B. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing 2021.
- C. NEMA TC 7 - Solid-Wall Coilable and Straight Electrical Polyethylene Conduit 2021.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings Current Edition, Including All Revisions.
- F. UL 651A - Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. Project Record Documents: Record actual routing and elevations of underground conduit and duct, and locations and sizes of manholes.

1.04 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 CONDUIT AND DUCT

- A. Rigid Polyvinyl Chloride (PVC) Conduit: NFPA 70, Type PVC; comply with NEMA TC 2 and list and label as complying with UL 651; Schedule 40 or Schedule 80 as indicated; rated for use with conductors rated 90 degrees C.
 - 1. Fittings: Comply with NEMA TC 3 and list and label as complying with UL 651.
 - a. Manufacturer: Same as manufacturer of conduit to be connected.
- B. High Density Polyethylene (HDPE) Conduit: NFPA 70, Type HDPE; comply with NEMA TC 7 and list and label as complying with UL 651A; Schedule 40 unless otherwise indicated.

2.02 ACCESSORIES

- A. Duct Bank Spacers: Nonmetallic; designed for maintaining conduit/duct spacing for concrete encasement in open trench installation; suitable for the conduit/duct arrangement to be installed.
- B. Underground Warning Tape: Polyethylene tape suitable for direct burial.
 - 1. Foil-backed Detectable Type Tape: 3 inches wide, with minimum thickness of 5 mil, unless otherwise required for proper detection.
 - 2. Legend: Type of service, continuously repeated over full length of tape.
 - 3. Color:
 - a. Tape for Buried Power Lines: Black text on red background.

- b. Tape for Buried Communication, Alarm, and Signal Lines: Black text on orange background.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify routing and termination locations of duct bank prior to excavation for rough-in.
- C. Duct bank routing is shown in approximate locations unless dimensions are indicated. Route as required to complete duct system.
- D. Manhole locations are shown in approximate locations unless dimensions are indicated. Locate as required to complete ductbank system.

3.02 DUCT BANK INSTALLATION

- A. Install duct to locate top of ductbank at depths as indicated on drawings.
- B. Install duct with minimum slope of 4 inches per 100 feet (0.33 percent). Slope duct away from building entrances.
- C. Cut duct square using saw or pipe cutter; de-burr cut ends.
- D. Insert duct to shoulder of fittings; fasten securely.
- E. Join nonmetallic duct using adhesive as recommended by manufacturer.
- F. Wipe nonmetallic duct dry and clean before joining. Apply full even coat of adhesive to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.
- G. Install no more than equivalent of three 90-degree bends between pull points.
- H. Provide suitable fittings to accommodate expansion and deflection where required.
- I. Stagger duct joints vertically in concrete encasement 6 inches minimum.
- J. Use suitable separators and chairs installed not greater than 4 feet on centers.
- K. Band ducts together before backfilling.
- L. Securely anchor duct to prevent movement during concrete placement.
- M. Place concrete under provisions of Section 03 30 00. Use mineral pigment to color concrete red.
- N. Provide concrete for encasement of underground ducts with 3000 psi minimum 28-day compressive strength.
- O. Provide minimum 3 inch concrete cover at bottom, top, and sides of ductbank.
- P. Provide two No. 4 steel reinforcing bars in top of bank under paved areas.
- Q. Connect to existing concrete encasement using dowels.
- R. Connect to manhole wall using dowels.
- S. Provide suitable pull string in each empty duct except sleeves and nipples.
- T. Swab duct. Use suitable caps to protect installed duct against entrance of dirt and moisture.

END OF SECTION

SECTION 26 05 53
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Voltage markers.
- D. Underground warning tape.
- E. Warning signs and labels.

1.02 REFERENCE STANDARDS

- A. ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs 2011 (Reaffirmed 2017).
- B. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels 2011 (Reaffirmed 2017).
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. NFPA 70E - Standard for Electrical Safety in the Workplace 2021.
- E. UL 969 - Marking and Labeling Systems Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.
- B. Sequencing:
 - 1. Do not conceal items to be identified, in locations such as above suspended ceilings, until identification products have been installed.
 - 2. Do not install identification products until final surface finishes and painting are complete.

1.04 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.05 FIELD CONDITIONS

- A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

PART 2 PRODUCTS

2.01 IDENTIFICATION REQUIREMENTS

- A. Existing Work: Unless specifically excluded, identify existing elements to remain that are not already identified in accordance with specified requirements.
- B. Identification for Equipment:
 - 1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
 - a. Switchboards:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Use identification nameplate to identify main overcurrent protective device.
 - 5) Use identification nameplate to identify load(s) served for each branch device. Identify spares and spaces.
 - b. Motor Control Centers:

- 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Use identification nameplate to identify main overcurrent protective device.
 - 5) Use identification nameplate to identify load(s) served for each branch device. Identify spares and spaces.
 - c. Panelboards:
 - 1) Identify ampere rating.
 - 2) Identify voltage and phase.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Identify main overcurrent protective device. Use identification label for panelboards with a door. For power distribution panelboards without a door, use identification nameplate.
 - 5) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces using pencil.
 - 6) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.
 - d. Transformers:
 - 1) Identify kVA rating.
 - 2) Identify voltage and phase for primary and secondary.
 - 3) Identify power source and circuit number. Include location when not within sight of equipment.
 - 4) Identify load(s) served. Include location when not within sight of equipment.
 - e. Enclosed switches, circuit breakers, and motor controllers:
 - 1) Identify voltage and phase.
 - 2) Identify power source and circuit number. Include location when not within sight of equipment.
 - 3) Identify load(s) served. Include location when not within sight of equipment.
 - f. Time Switches:
 - 1) Identify load(s) served and associated circuits controlled. Include location.
 - g. Enclosed Contactors:
 - 1) Identify load(s) and associated circuits controlled. Include location.
 - h. Transfer Switches:
 - 1) Identify voltage and phase.
 - 2) Identify power source and circuit number for both normal power source and standby power source. Include location when not within sight of equipment.
 - 3) Identify load(s) served. Include location when not within sight of equipment.
 - 4) Identify short circuit current rating based on the specific overcurrent protective device type and settings protecting the transfer switch.
 - i. Electricity Meters:
 - 1) Identify load(s) metered.
2. Service Equipment:
 - a. Use identification nameplate to identify each service disconnecting means.
 - b. For buildings or structures supplied by more than one service, or any combination of branch circuits, feeders, and services, use identification nameplate or means of identification acceptable to authority having jurisdiction at each service disconnecting means to identify all other services, feeders, and branch circuits supplying that building or structure. Verify format and descriptions with authority having jurisdiction.
3. Emergency System Equipment:
 - a. Use identification nameplate or voltage marker to identify emergency system equipment in accordance with NFPA 70.
 - b. Use identification nameplate at each piece of service equipment to identify type and location of on-site emergency power sources.

4. Use identification nameplate to identify equipment utilizing series ratings, where permitted, in accordance with NFPA 70.
 5. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.
 - a. Service equipment.
 - b. Industrial control panels.
 - c. Motor control centers.
 - d. Elevator control panels.
 - e. Industrial machinery.
 - f. Switchboards.
 - g. Distribution Panels
 - h. Panel Boards
 - i. Automatic Transfer Switches
 6. Arc Flash Hazard Warning Labels: Use warning labels to identify arc flash hazards for electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized.
 - a. Minimum Size: 3.5 by 5 inches.
 - b. Legend: Include orange header that reads "WARNING", followed by the word message "Arc Flash and Shock Hazard; Appropriate PPE Required; Do not operate controls or open covers without appropriate personal protection equipment; Failure to comply may result in injury or death; Refer to NFPA 70E for minimum PPE requirements" or approved equivalent.
 7. Use warning labels, identification nameplates, or identification labels to identify electrical hazards for equipment where multiple power sources are present with the word message "DANGER; Hazardous voltage; Multiple power sources may be present; Disconnect all electric power including remote disconnects before servicing" or approved equivalent.
- C. Identification for Conductors and Cables:
1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 05 19.
 2. Use underground warning tape to identify direct buried cables.
- D. Identification for Raceways:
1. Use voltage markers or color-coded bands to identify systems other than normal power system for accessible conduits at maximum intervals of 20 feet or at each junction point.
 - a. Color-Coded Bands: Use field-painting or vinyl color coding electrical tape to mark bands 2 inch(es) wide.
 - 1) Color Code:
 - (a) Code required emergency (Life Safety branch): Yellow
 - (b) Emergency Equipment branch: Green
 - (c) Emergency Critical branch: Orange
 - (d) Fire Alarm System: Red.
 - (e) Telecommunications: Blue
 - (f) Security: Purple
 - (g) Building Automation System: Blue
 - (h) Fiber Optic: White
 - 2) Vinyl Color Coding Electrical Tape: Comply with Section 26 05 19.
 2. Use identification labels, handwritten text using indelible marker, or plastic marker tags to identify circuits enclosed for accessible conduits at wall penetrations, at floor penetrations, at roof penetrations, and at equipment terminations when source is not within sight.
 3. Use identification labels, handwritten text using indelible marker, or plastic marker tags to identify spare conduits at each end. Identify purpose and termination location.
 4. Use underground warning tape to identify underground raceways.
- E. Identification for Boxes:

1. Use voltage markers or color coded boxes to identify systems other than normal power system.
 - a. Color-Coded Boxes: Field-painted per the following color code:
 - 1) Code required emergency (Life Safety Branch): Yellow
 - 2) Emergency Equipment Branch: Green
 - 3) Emergency Critical Branch: Orange
 - 4) Fire Alarm: Red
 - 5) Telecommunications: Blue
 - 6) Security: Purple
 - 7) Building Automation: Blue
 - 8) Fiber Optic: White
 - b. For exposed boxes in public areas, label the inside of the junction box cover.
 2. Use identification labels or handwritten text using indelible marker to identify circuits enclosed.
- F. Identification for Devices:
1. Use identification label to identify serving branch circuit for all receptacles.
 2. Use identification label or engraved wallplate to identify load controlled for wall-mounted control devices controlling loads that are not visible from the control location and for multiple wall-mounted control devices installed at one location.

2.02 IDENTIFICATION NAMEPLATES AND LABELS

- A. Identification Nameplates:
1. Materials:
 2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch; engraved text.
 3. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.
- B. Identification Labels:
1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
 - a. Use only for indoor locations.
 2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.
- C. Format for Equipment Identification:
1. Minimum Size: 1 inch by 2.5 inches.
 2. Legend:
 - a. Equipment designation or other approved description.
 3. Text: All capitalized unless otherwise indicated.
 4. Minimum Text Height:
 - a. Equipment Designation: 1/2 inch.
 - b. Other Information: 1/4 inch.
 5. Color:
 - a. Normal Power System: White text on black background.
 - b. Emergency Power System:
 - 1) Life Safety Branch: White text on Yellow background.
 - 2) Critical Branch: White text on Orange background.
 - 3) Equipment Branch: White text on Green background.
 - c. Fire Alarm System: White text on red background.

2.03 VOLTAGE MARKERS

- A. Markers for Conduits: Use factory pre-printed self-adhesive vinyl, self-adhesive vinyl cloth, or vinyl snap-around type markers.
- B. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.

- C. Minimum Size:
 - 1. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.
 - 2. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.
 - 3. Markers for Junction Boxes: 1/2 by 2 1/4 inches.
- D. Legend:
 - 1. Markers for System Identification:
- E. Color: Black text on orange background unless otherwise indicated.

2.04 UNDERGROUND WARNING TAPE

- A. Materials: Use non-detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.
- B. Non-detectable Type Tape: 6 inches wide, with minimum thickness of 4 mil.
- C. Legend: Type of service, continuously repeated over full length of tape.
- D. 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.

2.05 WARNING SIGNS AND LABELS

- A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B. Warning Signs:
 - 1. Materials:
 - 2. Minimum Size: 7 by 10 inches unless otherwise indicated.
- C. Warning Labels:
 - 1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
 - 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
 - 3. Minimum Size: 2 by 4 inches unless otherwise indicated.

PART 3 EXECUTION

3.01 PREPARATION

- A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
 - 1. Surface-Mounted Equipment: Enclosure front.
 - 2. Flush-Mounted Equipment: Inside of equipment door.
 - 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
 - 4. Elevated Equipment: Legible from the floor or working platform.
 - 5. Branch Devices: Adjacent to device.
 - 6. Interior Components: Legible from the point of access.
 - 7. Conduits: Legible from the floor.
 - 8. Boxes: Outside face of cover.
 - 9. Conductors and Cables: Legible from the point of access.
 - 10. Devices: Outside face of cover.
- C. Install identification products centered, level, and parallel with lines of item being identified.

- D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws or self-adhesive backing and to interior surfaces using self-adhesive backing or epoxy cement.
- E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.
- F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.
- G. In addition to equipment identification purposes, the plates attached to individually mounted circuit breakers, all panelboards, safety switches, and disconnects shall contain the following information: "Fed from (name of panel, circuit number, or switch feeding power to the device)".
- H. Provide warning signs and Arc flash labels required by NFPA 70, NFPA 70E, and by OSHA. Provide adhesive vinyl signs for indoor use and engraved plastic for outdoor use.
- I. Mark all handwritten text, where permitted, to be neat and legible.

3.03 FIELD QUALITY CONTROL

- A. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

**SECTION 26 05 73
POWER SYSTEM STUDIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Short-circuit study.
- B. Arc flash and shock risk assessment.
 - 1. Includes arc flash hazard warning labels.
- C. Criteria for the selection and adjustment of equipment and associated protective devices not specified in this section, as determined by studies to be performed.

1.02 RELATED REQUIREMENTS

- A. Section 26 05 53 - Identification for Electrical Systems: Additional requirements for arc flash hazard warning labels.

1.03 REFERENCE STANDARDS

- A. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels 2011 (Reaffirmed 2017).
- B. IEEE 141 - IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants 1993 (Reaffirmed 1999).
- C. IEEE 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems 2001, with Errata (2003).
- D. IEEE 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis 1997.
- E. IEEE 551 - IEEE Recommended Practice for Calculating Short-Circuit Currents in Industrial and Commercial Power Systems 2006.
- F. IEEE 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations 2018, with Errata (2019).
- G. NEMA MG 1 - Motors and Generators 2021.
- H. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- I. NFPA 70E - Standard for Electrical Safety in the Workplace 2021.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work to provide equipment and associated protective devices complying with criteria for selection and adjustment, as determined by studies to be performed.
- B. Sequencing:
 - 1. Submit study reports prior to or concurrent with product submittals.
 - 2. Do not order equipment until matching study reports and product submittals have both been evaluated by Architect.

1.05 SUBMITTALS

- A. Study reports, stamped or sealed and signed by study preparer.
- B. Product Data: In addition to submittal requirements specified in other sections, include manufacturer's standard catalog pages and data sheets for equipment and protective devices indicating information relevant to studies.
 - 1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
 - 2. Identify modifications made in accordance with studies that:
 - a. Can be made at no additional cost to Owner.
 - b. As submitted will involve a change to the contract sum.

- C. Arc Flash Hazard Warning Label Samples: One of each type and legend specified.

1.06 POWER SYSTEM STUDIES

A. Scope of Studies:

1. Except where study descriptions below indicate exclusions, analyze system at each bus from primary protective devices of utility source down to each piece of equipment involved, including parts of system affecting calculations being performed (e.g. fault current contribution from motors).
2. Include in analysis alternate sources and operating modes (including known future configurations) to determine worst case conditions.

B. General Study Requirements:

1. Comply with NFPA 70.
2. Perform studies utilizing computer software complying with specified requirements; manual calculations are not permitted.

C. Data Collection:

1. Compile information on project-specific characteristics of actual installed equipment, protective devices, feeders, etc. as necessary to develop single-line diagram of electrical distribution system and associated input data for use in system modeling.
 - a. Utility Source Data: Include primary voltage, maximum and minimum three-phase and line-to-ground fault currents, impedance, X/R ratio, and primary protective device information.
 - 1) Obtain up-to-date information from Utility Company.
 - b. Generators: Include manufacturer/model, kW and voltage ratings, and impedance.
 - c. Motors larger than 5Hp: Include manufacturer/model, type (e.g. induction, synchronous), horsepower rating, voltage rating, full load amps, and locked rotor current or NEMA MG 1 code letter designation.
 - d. Transformers: Include primary and secondary voltage ratings, kVA rating, winding configuration, percent impedance, and X/R ratio.
 - e. Protective Devices:
 - 1) Circuit Breakers: Include manufacturer/model, type (e.g. thermal magnetic, electronic trip), frame size, trip rating, voltage rating, interrupting rating, available field-adjustable trip response settings, and features (e.g. zone selective interlocking).
 - 2) Fuses: Include manufacturer/model, type/class (e.g. Class J), size/rating, and speed (e.g. time delay, fast acting).
 - f. Protective Relays: Include manufacturer/model, type, settings, current/potential transformer ratio, and associated protective device.
 - g. Conductors: Include feeder size, material (e.g. copper, aluminum), insulation type, voltage rating, number per phase, raceway type, and actual length.

D. Short-Circuit Study:

1. Comply with IEEE 551 and applicable portions of IEEE 141, IEEE 242, and IEEE 399.
2. For purposes of determining equipment short circuit current ratings, consider conditions that may result in maximum available fault current, including but not limited to:
 - a. Maximum utility fault currents.
 - b. Maximum motor contribution.
 - c. Known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).
3. For each bus location, calculate the maximum available three-phase bolted symmetrical and asymmetrical fault currents. For grounded systems, also calculate the maximum available line-to-ground bolted fault currents.

E. Arc Flash and Shock Risk Assessment:

1. Comply with NFPA 70E.
2. Perform incident energy and arc flash boundary calculations in accordance with IEEE 1584 (as referenced in NFPA 70E Annex D), where applicable.

3. Analyze alternate scenarios considering conditions that may result in maximum incident energy, including but not limited to:
 - a. Maximum and minimum utility fault currents.
 - b. Maximum and minimum motor contribution.
 - c. Known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).
- F. Study Reports:
 1. General Requirements:
 - a. Identify date of study and study preparer.
 - b. Identify study methodology and software product(s) used.
 - c. Identify scope of studies, assumptions made, implications of possible alternate scenarios, and any exclusions from studies.
 - d. Identify base used for per unit values.
 - e. Include single-line diagram and associated input data used for studies; identify buses on single-line diagram as referenced in reports, and indicate bus voltage.
 - f. Include conclusions and recommendations.
 2. Short-Circuit Study:
 - a. For each scenario, identify at each bus location:
 - 1) Calculated maximum available symmetrical and asymmetrical fault currents (both three-phase and line-to-ground where applicable).
 - 2) Fault point X/R ratio.
 - 3) Associated equipment short circuit current ratings.
 - b. Identify locations where the available fault current exceeds the equipment short circuit current rating, along with recommendations.
 3. Arc Flash and Shock Risk Assessment:
 - a. For the worst case for each scenario, identify at each bus location:
 - 1) Calculated incident energy and associated working distance.
 - 2) Calculated arc flash boundary.
 - 3) Bolted fault current.
 - 4) Arcing fault current.
 - 5) Clearing time.
 - 6) Arc gap distance.
 - b. For purposes of producing arc flash hazard warning labels, summarize the maximum incident energy and associated data reflecting the worst case condition of all scenarios at each bus location.

1.07 QUALITY ASSURANCE

- A. Study Preparer Qualifications: Professional electrical engineer licensed in the State in which the Project is located and with minimum five years experience in the preparation of studies of similar type and complexity using specified computer software.
- B. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.
 1. Acceptable Software Products:
 - a. SKM Systems Analysis, Inc: www.skm.com/#sle.

PART 2 PRODUCTS

2.01 ARC FLASH HAZARD WARNING LABELS

- A. Provide warning labels complying with ANSI Z535.4 to identify arc flash hazards for each work location analyzed by the arc flash and shock risk assessment.
 1. Materials: Comply with Section 26 05 53.
 2. Legend: Provide custom legend in accordance with NFPA 70E based on equipment-specific data as determined by arc flash and shock risk assessment.
 - a. Include the following information:
 - 1) Arc flash boundary.
 - 2) Available incident energy and corresponding working distance.

- 3) Nominal system voltage.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install arc flash warning labels in accordance with Section 26 05 53.

3.02 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Adjust equipment and protective devices for compliance with studies and recommended settings.
- C. Notify Architect of any conflicts with or deviations from studies. Obtain direction before proceeding.

END OF SECTION

**SECTION 26 05 83
WIRING CONNECTIONS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Electrical connections to equipment.

1.02 REFERENCE STANDARDS

- A. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2020).
- B. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2021.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
 - 2. Determine connection locations and requirements.
- B. Sequencing:
 - 1. Install rough-in of electrical connections before installation of equipment is required.
 - 2. Make electrical connections before required start-up of equipment.

1.04 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
 - 1. Colors: Conform to NEMA WD 1.
 - 2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
 - 3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.

2.02 EQUIPMENT CONNECTIONS

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.02 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

END OF SECTION

SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Occupancy sensors.
- B. Time switches.
- C. In-wall interval timers.
- D. Outdoor photo controls.
- E. Daylighting controls.
- F. Lighting contactors.

1.02 REFERENCE STANDARDS

- A. 47 CFR 15 - Radio Frequency Devices current edition.
- B. ANSI C136.24 - American National Standard for Roadway and Area Lighting Equipment - Nonlocking (Button) Type Photocontrols 2020.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- D. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- F. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts 2008 (Reaffirmed 2020).
- G. NEMA ICS 6 - Industrial Control and Systems: Enclosures 1993 (Reaffirmed 2016).
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 773A - Nonindustrial Photoelectric Switches for Lighting Control Current Edition, Including All Revisions.
- J. UL 916 - Energy Management Equipment Current Edition, Including All Revisions.
- K. UL 917 - Clock-Operated Switches Current Edition, Including All Revisions.
- L. UL 1472 - Solid-State Dimming Controls Current Edition, Including All Revisions.
- M. UL 60947-1 - Low-Voltage Switchgear and Controlgear - Part 1: General Rules Current Edition, Including All Revisions.
- N. UL 60947-4-1 - Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-starters - Electromechanical Contactors and Motor-starters Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of lighting control devices with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate the placement of wall switch occupancy sensors with actual installed door swings.
 - 3. Coordinate the placement of occupancy sensors with millwork, furniture, equipment or other potential obstructions to motion detection coverage installed under other sections or by others.
 - 4. Coordinate the placement of photo sensors for daylighting controls with windows, skylights, and luminaires to achieve optimum operation. Coordinate placement with ductwork, piping, equipment, or other potential obstructions to light level measurement installed under other sections or by others.
 - 5. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.04 SUBMITTALS

- A. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
- B. Shop Drawings:
 - 1. Occupancy Sensors: Provide lighting plan indicating location, model number, and orientation of each occupancy sensor and associated system component.
 - 2. Daylighting Controls: Provide lighting plan indicating location, model number, and orientation of each photo sensor and associated system component.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.06 DELIVERY, STORAGE, AND PROTECTION

- A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

PART 2 PRODUCTS

2.01 LIGHTING CONTROL DEVICES - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system.

2.02 OCCUPANCY SENSORS

- A. All Occupancy Sensors:
 - 1. Description: Factory-assembled commercial specification grade devices for indoor use capable of sensing both major motion, such as walking, and minor motion, such as small desktop level movements, according to published coverage areas, for automatic control of load indicated.
 - 2. Provide LED to visually indicate motion detection with separate color LEDs for each sensor type in dual technology units.
 - 3. Operation: Unless otherwise indicated, occupancy sensor to turn load on when occupant presence is detected and to turn load off when no occupant presence is detected during an adjustable turn-off delay time interval.
 - 4. Dual Technology Occupancy Sensors: Field configurable turn-on and hold-on activation with settings for activation by either or both sensing technologies.
 - 5. Passive Infrared Lens Field of View: Field customizable by addition of factory masking material, adjustment of integral blinders, or similar means to block motion detection in selected areas.
 - 6. Turn-Off Delay: Field adjustable, with time delay settings up to 30 minutes.
 - 7. Sensitivity: Field adjustable.
 - 8. Compatibility (Non-Dimming Sensors): Suitable for controlling incandescent lighting, low-voltage lighting with electronic and magnetic transformers, fluorescent lighting with electronic and magnetic ballasts, and fractional motor loads, with no minimum load requirements.
 - 9. Isolated Relay for Low Voltage Occupancy Sensors: SPDT dry contacts, ratings as required for interface with system indicated.
 - 10. Where wired sensors are indicated, wireless sensors are acceptable provided that all components and wiring modifications necessary for proper operation are included.
 - 11. Wireless Sensors:
 - a. RF Range: 30 feet through typical construction materials.
 - b. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B application.
 - c. Power: Battery-operated with minimum ten-year battery life.
- B. Wall Switch Occupancy Sensors:
 - 1. All Wall Switch Occupancy Sensors:

- a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with a field of view of 180 degrees, integrated manual control capability, and no leakage current to load in off mode.
 - b. Manual-Off Override Control: When used to turn off load while in automatic-on mode, unit to revert back to automatic mode after no occupant presence is detected during the delayed-off time interval.
 - c. Finish: Match finishes specified for wiring devices in Section 26 27 26, unless otherwise indicated.
 - d. Field selectable for vacancy or occupancy mode.
- C. Wall Dimmer Occupancy Sensors:
 - 1. General Requirements:
 - a. Description: Occupancy sensors designed for installation in standard wall box at standard wall switch mounting height with a field of view of 180 degrees, integrated dimming control capability , and no leakage current to load in off mode.
 - b. Dimmer: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, and listed as complying with UL 1472; type and rating suitable for load controlled.
 - c. Finish: Match finishes specified for wiring devices in Section 26 27 26, unless otherwise indicated.
- D. Ceiling Mounted Occupancy Sensors:
 - 1. All Ceiling Mounted Occupancy Sensors:
 - a. Description: Low profile occupancy sensors designed for ceiling installation.
 - b. Unless otherwise indicated or required to control the load indicated on drawings, provide low voltage units, for use with separate compatible accessory power packs.
 - c. Provide field selectable setting for disabling LED motion detector visual indicator.
 - d. Occupancy sensor to be field selectable as either manual-on/automatic-off or automatic on/off.
 - e. Finish: White unless otherwise indicated.
- E. Power Packs for Low Voltage Occupancy Sensors:
 - 1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage occupancy sensors for switching of line voltage loads.
 - 2. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
 - 3. Input Supply Voltage: Dual rated for 120/277 V ac.
 - 4. Load Rating: As required to control the load indicated on drawings.
- F. Power Packs for Wireless Occupancy Sensors:
 - 1. Description: Plenum rated, self-contained relay compatible with specified wireless occupancy sensors for switching of line voltage loads.
 - 2. Input Supply Voltage: Dual rated for 120/277 V ac.
 - 3. Load Rating: As required to control the load indicated on drawings.

2.03 TIME SWITCHES

- A. Digital Electronic Time Switches:
 - 1. Description: Factory-assembled solid state programmable controller with LCD display, listed and labeled as complying with UL 916 or UL 917.
 - 2. Program Capability:
 - a. Astronomic Time Switches: Single channel, capable of different schedule for each day of the week with additional holiday schedule available to override normal schedule for selected days and field-configurable astronomic feature to automatically adjust for seasonal changes in sunrise and sunset times.
 - 3. Schedule Capacity: Not less than 16 programmable on/off operations.
 - 4. Provide automatic daylight savings time and leap year compensation.

5. Provide power outage backup to retain programming and maintain clock.
6. Manual override: Capable of overriding current schedule both permanently and temporarily until next scheduled event.
7. Input Supply Voltage: As required for application.
8. Provide lockable enclosure; environmental type per NEMA 250 as specified for the following installation locations:
 - a. Indoor clean, dry locations: Type 1.

2.04 IN-WALL INTERVAL TIMERS

- A. Digital Electronic In-Wall Interval Timers:
 1. Description: Factory-assembled solid state programmable controller with LCD display, suitable for mounting in standard wall box, and listed and labeled as complying with UL 916 or UL 917.
 2. Program Capability: Designed to turn load off at end of preset time interval.
 3. Time Interval: Field selectable range of presets available up to 12 hours.
 4. Provide field selectable audible and visual indication to warn that end of interval operation is about to turn off load.
 5. Provide power outage backup to retain programming and maintain clock.
 6. Manual override: Capable of both turning load off and resetting timer to original preset time interval.
 7. Switch Configuration: Suitable for use in either SPST or 3-way application.

2.05 OUTDOOR PHOTO CONTROLS

- A. Button Type Outdoor Photo Controls
 1. Description: Direct-wired photo control unit complying with ANSI C136.24 with weatherproof gasketed wall plate where required or indicated, listed and labeled as complying with UL 773A.
 2. Housing: Weather resistant polycarbonate.
 3. Photo Sensor: Cadmium sulfide.
 4. Light Level Activation: 1 to 3 footcandles turn-on and 3 to 1 turn-off to turn-on ratio with delayed turn-off.
 5. Voltage: As required to control the load indicated on the drawings.
 6. Failure Mode: Fails to the on position.
 7. Load Rating: As required to control the load indicated on the drawings.

2.06 LIGHTING CONTACTORS

- A. Description: Magnetic lighting contactors complying with NEMA ICS 2, and listed and labeled as complying with UL 60947-1 and UL 60947-4-1; noncombination type unless otherwise indicated; ratings, configurations and features as indicated on the drawings.
- B. Short Circuit Current Rating:
 1. Provide contactors with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
- C. Enclosures:
 1. Comply with NEMA ICS 6.
 2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1 or Type 12.
 3. Finish: Manufacturer's standard unless otherwise indicated.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

- C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.
- G. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install lighting control devices in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of lighting control devices provided under this section.
- C. Install lighting control devices in accordance with manufacturer's instructions.
- D. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E. Install lighting control devices plumb and level, and held securely in place.
- F. Where required and not furnished with lighting control device, provide wall plate in accordance with Section 26 27 26.
- G. Provide required supports in accordance with Section 26 05 29.
- H. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- I. Outdoor Photo Control Locations:
 - 1. Where possible, locate outdoor photo controls with photo sensor facing north. If north facing photo sensor is not possible, install with photo sensor facing east, west, or down.
 - 2. Locate outdoor photo controls so that photo sensors do not face artificial light sources, including light sources controlled by the photo control itself.
- J. Install outdoor photo controls so that connections are weatherproof. Do not install photo controls with conduit stem facing up in order to prevent infiltration of water into the photo control.

END OF SECTION

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SECTION 26 21 00
LOW-VOLTAGE ELECTRICAL SERVICE ENTRANCE

PART 1 GENERAL

1.01 RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- C. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.

1.02 REFERENCE STANDARDS

- A. IEEE C2 - National Electrical Safety Code(R) (NESC(R)) 2023.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 QUALITY ASSURANCE

- A. Comply with the following:
 - 1. IEEE C2 (National Electrical Safety Code).
 - 2. NFPA 70 (National Electrical Code).
 - 3. The requirements of the Utility Company.

PART 2 PRODUCTS

2.01 ELECTRICAL SERVICE REQUIREMENTS

- A. Provide new electrical service consisting of all required conduits, conductors, equipment, metering provisions, supports, accessories, etc. as necessary for connection between Utility Company point of supply and service entrance equipment.
- B. Products Furnished by Contractor: Comply with Utility Company requirements.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install products in accordance with manufacturer's instructions and Utility Company requirements.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Provide required support and attachment components in accordance with Section 26 05 29.
- E. Provide grounding and bonding for service entrance equipment in accordance with Section 26 05 26.
- F. Identify service entrance equipment, including main service disconnect(s) in accordance with Section 26 05 53.
- G. Underground service laterals shall use minimum 4" PVC.
- H. Provide minimum one space conduits in duct bank.

END OF SECTION

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**SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. General purpose transformers.

1.02 REFERENCE STANDARDS

- A. 10 CFR 431, Subpart K - Energy Efficiency Program for Certain Commercial and Industrial Equipment - Distribution Transformers Current Edition.
- B. IEEE C57.94 - IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type Distribution and Power Transformers 2015.
- C. IEEE C57.96 - IEEE Standard Guide for Loading Dry-Type Distribution and Power Transformers 2013.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- E. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers 2015.
- F. NEMA ST 20 - Dry Type Transformers for General Applications 2021.
- G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 506 - Standard for Specialty Transformers Current Edition, Including All Revisions.
- J. UL 1561 - Standard for Dry-Type General Purpose and Power Transformers Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with placement of supports, anchors, etc. required for mounting.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. Product Data: Include voltage, kVA, impedance, tap configurations, insulation system class and rated temperature rise, efficiency, sound level, enclosure ratings, outline and support point dimensions, weight, required clearances, service condition requirements, and installed features.
- B. Shop Drawings: Provide dimensioned plan and elevation views of transformers and adjacent equipment with all required clearances indicated.
- C. Specification Compliance Review

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

- B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB/GE: www.geindustrial.com/#sle.
- B. Eaton Corporation: www.eaton.com/#sle.
- C. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.
- D. Siemens Industry, Inc: www.usa.siemens.com/#sle.
- E. Powersmiths.

2.02 TRANSFORMERS - GENERAL REQUIREMENTS

- A. Description: Factory-assembled, dry type transformers for 60 Hz operation designed and manufactured in accordance with NEMA ST 20 and listed, classified, and labeled as suitable for the purpose intended.
- B. Unless noted otherwise, transformer ratings indicated are for continuous loading according to IEEE C57.96 under the following service conditions:
 - 1. Altitude: Less than 3,300 feet.
 - 2. Ambient Temperature:
 - a. Greater than 10 kVA: Not exceeding 104 degrees F.
 - b. Less than 10 kVA: Not exceeding 77 degrees F.
- C. Core: High grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Keep magnetic flux densities substantially below saturation point, even at 10 percent primary overvoltage. Tightly clamp core laminations to prevent plate movement and maintain consistent pressure throughout core length.
- D. Impregnate core and coil assembly with non-hydroscopic thermo-setting varnish to effectively seal out moisture and other contaminants.
- E. Basic Impulse Level: 10 kV.
- F. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.
- G. Isolate core and coil from enclosure using vibration-absorbing mounts.
- H. Nameplate: Include transformer connection data, ratings, wiring diagrams, and overload capacity based on rated winding temperature rise.

2.03 GENERAL PURPOSE TRANSFORMERS

- A. Description: Self-cooled, two winding transformers listed and labeled as complying with UL 506 or UL 1561; ratings as indicated on the drawings.
- B. Insulation System and Allowable Average Winding Temperature Rise:
 - 1. Less than 15 kVA: Class 180 degrees C insulation system with 115 degrees C average winding temperature rise.
 - 2. 15 kVA and Larger: Class 220 degrees C insulation system with 150 degrees C average winding temperature rise.
- C. Coil Conductors: Continuous aluminum windings with terminations brazed or welded.
- D. Winding Taps:
 - 1. Less than 3 kVA: None.
 - 2. 3 kVA through 15 kVA: Two 5 percent full capacity primary taps below rated voltage.
 - 3. 15 kVA through 300 kVA: Two 2.5 percent full capacity primary taps above and four 2.5 percent full capacity primary taps below rated voltage.
 - 4. 500 kVA and Larger: Two 2.5 percent full capacity primary taps above and two 2.5 percent full capacity primary taps below rated voltage.

- E. Energy Efficiency: Comply with 10 CFR 431, Subpart K.
- F. Sound Levels: Standard sound levels complying with NEMA ST 20
- G. Mounting Provisions:
 - 1. Less than 15 kVA: Suitable for wall mounting.
 - 2. 15 kVA through 75 kVA: Suitable for wall, floor, or trapeze mounting.
 - 3. Larger than 75 kVA: Suitable for floor mounting.
- H. Transformer Enclosure: Comply with NEMA ST 20.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - 2. Construction: Steel.
 - a. Less than 15 kVA: Totally enclosed, non-ventilated.
 - b. 15 kVA and Larger: Ventilated.
 - 3. Finish: Manufacturer's standard grey, suitable for outdoor installations.
 - 4. Provide lifting eyes or brackets.
- I. Accessories:
 - 1. Mounting Brackets: Provide manufacturer's standard brackets.
 - 2. Lug Kits: Sized as required for termination of conductors as indicated on the drawings.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that suitable support frames and anchors are installed where required and that mounting surfaces are ready to receive transformers.
- C. Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install transformers in accordance with NECA 409 and IEEE C57.94.
- D. Use flexible conduit, under the provisions of Section 26 05 33.13, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
- E. Arrange equipment to provide minimum clearances as specified on transformer nameplate and in accordance with manufacturer's instructions and NFPA 70.
- F. Install transformers plumb and level.
- G. Transformer Support:
 - 1. Provide required support and attachment in accordance with Section 26 05 29, where not furnished by transformer manufacturer.
 - 2. Use integral transformer flanges, accessory brackets furnished by manufacturer, or field-fabricated supports to support wall-mounted transformers.
 - 3. Unless otherwise indicated, mount floor-mounted transformers on properly sized 3 inch high concrete pad constructed in accordance with concrete Section.
 - 4. Use trapeze hangers assembled from threaded rods and metal channel (strut) to support suspended transformers. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- H. Provide grounding and bonding in accordance with Section 26 05 26.
- I. Remove shipping braces and adjust bolts that attach the core and coil mounting bracket to the enclosure according to manufacturer's recommendations in order to reduce audible noise transmission.

- J. Where not factory-installed, install lugs sized as required for termination of conductors as indicated.

3.03 ADJUSTING

- A. Measure primary and secondary voltages and make appropriate tap adjustments.
- B. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.04 CLEANING

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

END OF SECTION

SECTION 26 24 13 SWITCHBOARDS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Low-voltage (600 V and less) switchboards and associated accessories for service and distribution applications.
- B. Overcurrent protective devices for switchboards.

1.02 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e, with Amendment (2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 400 - Standard for Installing and Maintaining Switchboards 2007.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- E. NEMA PB 2 - Deadfront Distribution Switchboards 2011.
- F. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less 2013.
- G. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
- J. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.
- K. UL 891 - Switchboards Current Edition, Including All Revisions.
- L. UL 1053 - Ground-Fault Sensing and Relaying Equipment Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Coordinate with manufacturer to provide shipping splits suitable for the dimensional constraints of the installation.
 - 6. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- B. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.

1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
 2. The electrical contractor is responsible for coordinating overcurrent protection devices size, rating, and type with equipment supplied by all parties. Modifications to breaker sizes indicated on plans shall not constitute a cost change to the project. Identify overcurrent protection revisions on the shop drawings.
- C. Specification Compliance Review
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 60 00 - Product Requirements, for additional provisions.
 2. Enclosure Keys: Two of each different key.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store switchboards in accordance with manufacturer's instructions, NECA 400, and NEMA PB 2.1.
- B. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.
- C. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- D. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Switchboards:
1. ABB/GE: www.geindustrial.com/#sle.
 2. Eaton Corporation: www.eaton.com/#sle.
 3. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.
 4. Siemens Industry, Inc: www.usa.siemens.com/#sle.
- B. Source Limitations: Furnish switchboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 SWITCHBOARDS

- A. Provide switchboards consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Description: Dead-front switchboard assemblies complying with NEMA PB 2, and listed and labeled as complying with UL 891; ratings, configurations and features as indicated on the drawings.
- D. Front-Connected Switchboards:
1. Main Device(s): Panel/group-mounted or individually-mounted.
 2. Feeder Devices: Panel/group-mounted.
 3. Arrangement: Front accessible only (not rear accessible), rear aligned.
 4. Gutter Access: Hinged doors.
- E. Service Entrance Switchboards:
1. Listed and labeled as suitable for use as service equipment according to UL 869A.
 2. For solidly-grounded wye systems, provide factory-installed main bonding jumper between neutral and ground busses, and removable neutral disconnecting link for testing purposes.

3. Comply with Utility Company requirements for electrical service.
- F. Service Conditions:
 1. Provide switchboards and associated components suitable for operation under the following service conditions without derating:
 - a. Altitude: Less than 6,600 feet.
 - b. Ambient Temperature:
 - 1) Switchboards Containing Molded Case or Insulated Case Circuit Breakers: Between 23 degrees F and 104 degrees F.
 2. Provide switchboards and associated components suitable for operation at indicated ratings under the service conditions at the installed location.
- G. Short Circuit Current Rating:
 1. Provide switchboards with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
- H. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.
- I. Main Devices: Configure for top or bottom incoming feed as indicated or as required for the installation. Provide separate pull section and/or top-mounted pullbox as indicated or as required to facilitate installation of incoming feed.
- J. Bussing: Sized in accordance with UL 891 temperature rise requirements.
 1. Through bus (horizontal cross bus) to be fully rated through full length of switchboard (non-tapered). Tapered bus is not permitted.
 2. Provide solidly bonded equipment ground bus through full length of switchboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
 3. Phase and Neutral Bus Material: Aluminum.
 4. Ground Bus Material: Aluminum.
- K. Conductor Terminations: Suitable for use with the conductors to be installed.
 1. Line Conductor Terminations:
 - a. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - b. Main and Neutral Lug Type: Mechanical.
 2. Load Conductor Terminations:
 - a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - b. Lug Type:
 - 1) Provide mechanical lugs unless otherwise indicated.
- L. Enclosures:
 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1 or Type 2 (drip-proof).
 2. Finish: Manufacturer's standard unless otherwise indicated.
 3. Outdoor Enclosures:
 - a. Color: Manufacturer's standard.
 - b. Access Doors: Lockable, with all locks keyed alike.
- M. Future Provisions:
 1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
 2. Equip distribution sections with full height vertical bussing to accommodate maximum utilization of space for devices.
 3. Arrange and equip through bus and ground bus to accommodate future installation of additional switchboard sections.
- N. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00, list switchboards as a complete assembly

including surge protective device.

- O. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
- P. Arc Flash Energy-Reducing Maintenance Switching: For circuit breakers rated 1200 A or higher, provide a local accessory switch with status indicator light that permits selection of a maintenance mode with alternate electronic trip unit settings for reduced fault clearing time.
- Q. Owner Metering:
 - 1. Provide microprocessor-based digital electrical metering system including all instrument transformers, wiring, and connections necessary for measurements specified.
 - 2. Measured Parameters:
 - a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
 - b. Current (Amps): For each phase and neutral.
 - c. Frequency (Hz).
 - d. Real power (kW): For each phase, 3-phase total.
 - e. Reactive power (kVAR): For each phase, 3-phase total.
 - f. Apparent power (kVA): For each phase, 3-phase total.
 - g. Power factor.
 - h. Current demand.
 - 3. Meter Accuracy: Plus/minus 1.0 percent.
 - 4. Features:
 - a. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
 - b. Adjustable demand interval.
 - c. Remote monitoring capability via PC.
- R. Instrument Transformers:
 - 1. Comply with IEEE C57.13.
 - 2. Select suitable ratio, burden, and accuracy as required for connected devices.
 - 3. Current Transformers: Connect secondaries to shorting terminal blocks.
 - 4. Potential Transformers: Include primary and secondary fuses with disconnecting means.

2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Circuit Breakers:
 - 1. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
 - 2. Molded Case Circuit Breakers:
 - a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 - 1) Provide electronic trip circuit breakers for circuit breaker frame sizes 100 amperes and above.
 - b. Minimum Interrupting Capacity:
 - 1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - 2) 14,000 rms symmetrical amperes at 480 VAC.
 - c. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 - d. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - 1) Provide the following field-adjustable trip response settings:

- (a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
 - (b) Long time delay.
 - (c) Short time pickup and delay.
 - (d) Instantaneous pickup.
 - (e) Ground fault pickup and delay where ground fault protection is indicated.
 - e. Provide the following circuit breaker types where indicated:
 - 1) 100 Percent Rated Circuit Breakers: Listed for application within the switchboard where installed at 100 percent of the continuous current rating.
 - 2) Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
 - f. Provide the following features and accessories where indicated or where required to complete installation:
 - 1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
- 3. Insulated Case Circuit Breakers:
 - a. Description: Quick-make, quick-break, trip-free circuit breakers with two-step stored energy closing mechanism; standard 80 percent rated unless otherwise indicated; listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
 - b. Operation:
 - 1) Provide manually operated circuit breakers unless otherwise indicated.
 - 2) Pad-Lock Provision: For preventing circuit breaker closing operation.
 - c. Minimum Interrupting Capacity:
 - 1) 42,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - 2) 65,000 rms symmetrical amperes at 480 VAC.
 - d. Trip Units: Solid state, microprocessor-based, true rms sensing.
 - 1) Provide the following field-adjustable trip response settings:
 - (a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
 - (b) Long time delay.
 - (c) Short time pickup and delay.
 - (d) Instantaneous pickup.
 - (e) Ground fault pickup and delay where ground fault protection is indicated.

2.04 SOURCE QUALITY CONTROL

- A. Factory test switchboards according to NEMA PB 2, including the following production (routine) tests on each switchboard assembly or component:
 - 1. Dielectric tests.
 - 2. Mechanical operation tests.
 - 3. Grounding of instrument transformer cases test.
 - 4. Electrical operation and control wiring tests, including polarity and sequence tests.
 - 5. Ground-fault sensing equipment test.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the switchboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive switchboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install switchboards in accordance with NECA 1 (general workmanship), NECA 400, and NEMA PB 2.1.
- C. Arrange equipment to provide required clearances and maintenance access, including accommodations for any drawout devices.
- D. Where switchboard is indicated to be mounted with inaccessible side against wall, provide minimum clearance of 1/2 inch between switchboard and wall.
- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Install switchboards plumb and level.
- G. Unless otherwise indicated, mount switchboards on properly sized 4 inch high concrete pad constructed in accordance with concrete Section.
- H. Provide grounding and bonding in accordance with Section 26 05 26.
- I. Install all 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 circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed in accordance with Section 26 05 73.
- L. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- M. Provide filler plates to cover unused spaces in switchboards.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.
- C. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.
- D. Inspect and test in accordance with NETA ATS, except Section 4.
- E. Perform inspections and tests listed in NETA ATS, Section 7.1.
- F. Molded Case and Insulated Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than [] amperes. Tests listed as optional are not required.
- G. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
 - 1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.
- H. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.
- I. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10. The dielectric withstand tests on primary windings with secondary windings connected to ground listed as optional are not required.
- J. Test shunt trips to verify proper operation.
- K. Correct deficiencies and replace damaged or defective switchboards or associated components.

3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of switchboard covers and doors.

3.05 CLEANING

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

3.06 CLOSEOUT ACTIVITIES

- A. Training: Train Owner's personnel on operation, adjustment, and maintenance of switchboard 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.

3.07 PROTECTION

- A. Protect installed switchboards from subsequent construction operations.

END OF SECTION

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**SECTION 26 24 16
PANELBOARDS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Power distribution panelboards.
- B. Lighting and appliance panelboards.
- C. Fused Coordination Panels
- D. Overcurrent protective devices for panelboards.

1.02 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service 2013e, with Amendment (2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards 2015.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- E. NEMA PB 1 - Panelboards 2011.
- F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less 2013.
- G. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- H. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- K. UL 67 - Panelboards Current Edition, Including All Revisions.
- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.
- M. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.
- N. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.
- O. UL 1053 - Ground-Fault Sensing and Relaying Equipment Current Edition, Including All Revisions.
- P. UL 1699 - Arc-Fault Circuit-Interrupters Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- B. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
 - 2. The electrical contractor is responsible for coordinating overcurrent protection devices size, rating, and type with equipment supplied by all parties. Modifications to breaker sizes indicated on plans shall not constitute a cost change to the project. Identify overcurrent protection revisions on the shop drawings.
- C. Specification Compliance Review
- D. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Panelboard Keys: Two of each different key.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB/GE: www.geindustrial.com/#sle.
- B. Eaton Corporation: www.eaton.com/#sle.
- C. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.
- D. Siemens Industry, Inc: www.usa.siemens.com/#sle.
- E. Source Limitations: Furnish panelboards and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 PANELBOARDS - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Short Circuit Current Rating:
 - 1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73.
- C. Panelboards Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- F. Bussing: Sized in accordance with UL 67 temperature rise requirements.

1. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- G. Conductor Terminations: Suitable for use with the conductors to be installed.
- H. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 2. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide wiring gutters sized to accommodate the conductors to be installed.
 - b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
 3. Fronts:
 - a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
 - b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
 - c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- J. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00, list and label panelboards as a complete assembly including surge protective device.
- K. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
 1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
- L. Multi-Section Panelboards: Provide enclosures of the same height, with feed-through lugs or sub-feed lugs and feeders as indicated or as required to interconnect sections.

2.03 POWER DISTRIBUTION PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
 1. Phase and Neutral Bus Material: Aluminum.
 2. Ground Bus Material: Aluminum.
- D. Circuit Breakers:
 1. Provide bolt-on type.
 2. Provide electronic trip circuit breakers for circuit breaker frame sizes 100 amperes and above.
- E. Enclosures:
 1. Provide surface-mounted enclosures unless otherwise indicated.
 2. Fronts: Provide trims to cover access to load terminals, wiring gutters, and other live parts, with exposed access to overcurrent protective device handles.

2.04 LIGHTING AND APPLIANCE PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:
 - 1. Main and Neutral Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
 - 1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
 - 2. Phase and Neutral Bus Material: Aluminum.
 - 3. Ground Bus Material: Aluminum.
- D. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.
- E. Enclosures:
 - 1. Provide surface-mounted or flush-mounted enclosures as indicated.
 - 2. Fronts: Provide door-in-door trim with hinged cover for access to load terminals and wiring gutters, and separate lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
 - 3. Provide clear plastic circuit directory holder mounted on inside of door.

2.05 OVERCURRENT PROTECTIVE DEVICES

- A. Molded Case Circuit Breakers:
 - 1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 - 2. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - 1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
 - 3. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
 - 4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
 - a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
 - 5. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - 6. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
 - 7. Provide the following circuit breaker types where indicated:
 - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
 - b. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
 - c. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
 - d. 100 Percent Rated Circuit Breakers: Listed for application within the panelboard where installed at 100 percent of the continuous current rating.
 - 8. Do not use tandem circuit breakers.
 - 9. Provide multi-pole circuit breakers for multi-wire branch circuits as required by NFPA 70.

10. Provide the following features and accessories where indicated or where required to complete installation:
 - a. Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
 - b. Handle Pad-Lock Provision: For locking circuit breaker handle in OFF position.

2.06 SOURCE QUALITY CONTROL

- A. Factory test panelboards according to NEMA PB 1.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Install panelboards plumb.
- G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- I. Mount floor-mounted power distribution panelboards on properly sized 3 inch high concrete pad constructed in accordance with concrete Section.
- J. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- K. A minimum of one 3/4" conduit shall be installed for every three single pole spare circuit or space, or fraction thereof, but not less than two conduit.
- L. Provide grounding and bonding in accordance with Section 26 05 26.
- M. Install all field-installed branch devices, components, and accessories.
- N. Provide fuses complying with Section 26 28 13 for fusible switches as indicated.
- O. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed according to Section 26 05 73.
- P. Set field-adjustable ground fault protection pickup and time delay settings as indicated.
- Q. Provide filler plates to cover unused spaces in panelboards.
- R. Panel directories shall match the graphic design package. Contractor documents shall be noted accordingly.
- S. New typewritten directories shall be provided for all panelboards.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.

- C. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by NFPA 70.
- D. Test GFCI circuit breakers to verify proper operation.
- E. Test AFCI circuit breakers to verify proper operation.
- F. Test shunt trips to verify proper operation.
- G. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.04 ADJUSTING

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

3.05 CLEANING

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

END OF SECTION

**SECTION 26 27 13
ELECTRICITY METERING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Equipment for Owner electricity metering:
 - 1. Single circuit electricity meters.

1.02 REFERENCE STANDARDS

- A. ANSI C12.1 - Electric Meters - Code for Electricity Metering 2022.
- B. ANSI C12.20 - American National Standard for Electricity Meters - 0.1, 0.2, and 0.5 Accuracy Classes 2018, with Errata.
- C. IEC 62053-21 - Electricity Metering Equipment - Particular Requirements - Part 21: Static Meters for AC Active Energy (Classes 0.5, 1 and 2) 2020.
- D. IEC 62053-23 - Electricity Metering Equipment - Particular Requirements - Part 23: Static Meters for Reactive Energy (Classes 2 and 3) 2020.
- E. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers 2016.
- F. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- G. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- H. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- I. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate work to provide equipment suitable for interface with electricity metering systems to be provided.
 - 2. Coordinate the work with other installers to provide communication lines required for electricity metering system interface.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for electricity metering systems and associated components and accessories. Include ratings, configurations, standard wiring diagrams, dimensions, service condition requirements, and installed features.
- B. Shop Drawings: Include system interconnection schematic diagrams showing all factory and field connections. Include requirements for interface with other systems.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Enclosure Keys: Two of each different key.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Source Limitations: Furnish electricity meters produced by a single manufacturer and obtained from a single supplier.

2.02 EQUIPMENT FOR OWNER ELECTRICITY METERING

- A. Provide microprocessor-based digital electricity metering systems including all instrument transformers, wiring, and connections necessary for measurements specified.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Provide electricity metering systems and associated components compatible with the equipment and associated circuits to be metered.
- D. Enclosures:
 - 1. Environment Type per NEMA 250: As indicated on the drawings.
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R or Type 4.
 - 2. Finish: Manufacturer's standard unless otherwise indicated.
- E. Instrument Transformers:
 - 1. Comply with IEEE C57.13, where applicable.
 - 2. Select suitable ratio, burden, and accuracy as required for connected devices.
 - 3. Current Transformers: Compatible with connected meters; replace meters damaged by connection of incompatible current transformers. Provide shorting terminal blocks for connection of secondaries where applicable.
 - 4. Potential Transformers: Include primary and secondary fuses with disconnecting means.

2.03 SINGLE CIRCUIT ELECTRICITY METERS

- A. Single Circuit Electricity Meter:
 - 1. Accuracy:
 - a. Real/Active Power/Energy: Revenue grade; plus/minus 1.0 percent; complying with ANSI C12.1 and/or IEC 62053-21 Class 1.
 - b. Reactive Power/Energy: Plus/minus 2.0 percent, complying with IEC 62053-23 Class 2.
 - 2. Measured Parameters:
 - a. Current (Amps); per phase.
 - b. Frequency (Hz).
 - c. Real/active power (kW); per phase and total of all phases.
 - d. Reactive power (kVAR); per phase and total of all phases.
 - e. Apparent power (kVA); per phase and total of all phases.
 - f. Power factor; per phase and total of all phases.
 - g. Real/active energy (kWh).
 - h. Reactive energy (kVARh).
 - i. Apparent energy (kVAh).
 - j. Power demand; real/active, reactive, and apparent; present and maximum.
 - 3. Data logging.
 - a. Storage Capacity: 30 days of readings at 15 minute intervals.
 - 4. Communications: Compatible with connected systems. Provide all accessories necessary for proper interface.
 - a. Ethernet Communications: Support for Modbus TCP protocol.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of metering systems and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive meters.
- D. Verify that conditions are satisfactory for installation prior to starting work.

- E. Provide circuits and breaker as required for meter sensing voltages.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Provide required support and attachment components in accordance with Section 26 05 29.
- D. Provide grounding and bonding in accordance with Section 26 05 26.
- E. Provide fuses complying with Section 26 28 13 as required.

3.03 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.
- C. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10. The dielectric withstand tests on primary windings with secondary windings connected to ground listed as optional are not required.
- D. Correct deficiencies and replace damaged or defective metering system components.

3.04 ADJUSTING

- A. Program system parameters according to requirements of Owner.

3.05 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.06 CLOSEOUT ACTIVITIES

- A. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
 - 1. Provide minimum of two hours of training.
 - 2. Instructor: Manufacturer's authorized representative.
 - 3. Location: At project site.

3.07 PROTECTION

- A. Protect installed system components from subsequent construction operations.

END OF SECTION

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**SECTION 26 27 26
WIRING DEVICES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Wall switches.
- B. Wall dimmers.
- C. Fan speed controllers.
- D. Receptacles.
- E. Wall plates.

1.02 REFERENCE STANDARDS

- A. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification) 2014g, with Amendment (2017).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- C. NECA 130 - Standard for Installing and Maintaining Wiring Devices 2016.
- D. NEMA WD 1 - General Color Requirements for Wiring Devices 1999 (Reaffirmed 2020).
- E. NEMA WD 6 - Wiring Devices - Dimensional Specifications 2021.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. UL 20 - General-Use Snap Switches Current Edition, Including All Revisions.
- H. UL 498 - Attachment Plugs and Receptacles Current Edition, Including All Revisions.
- I. UL 514D - Cover Plates for Flush-Mounted Wiring Devices Current Edition, Including All Revisions.
- J. UL 943 - Ground-Fault Circuit-Interrupters Current Edition, Including All Revisions.
- K. UL 1310 - Class 2 Power Units Current Edition, Including All Revisions.
- L. UL 1472 - Solid-State Dimming Controls Current Edition, Including All Revisions.
- M. UL 1917 - Solid-State Fan Speed Controls Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
 - 3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
 - 4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
- B. Sequencing:
 - 1. Do not install wiring devices until final surface finishes and painting are complete.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.06 DELIVERY, STORAGE, AND PROTECTION

- A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS

2.01 WIRING DEVICE APPLICATIONS

- A. Hospital grade receptacles shall be used throughout.
- B. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- C. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- D. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles indicated on the plans.
- E. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- F. Provide GFCI protection for receptacles installed in kitchens.
- G. Provide GFCI protection for receptacles serving electric drinking fountains.
- H. Provide GFCI protection for circuits serving electric drinking fountains.

2.02 WIRING DEVICE FINISHES

- A. Provide wiring device finishes as described below unless otherwise indicated.
- B. Wiring Devices, Unless Otherwise Indicated: White with white nylon wall plate.
- C. Wiring Devices Installed in Unfinished Spaces: Gray with galvanized steel wall plate.
- D. Wiring Devices Connected to Emergency Power: Red with red nylon wall plate factory marked "Emergency".

2.03 WALL SWITCHES

- A. Manufacturers:
 - 1. Hubbell Incorporated: www.hubbell.com/#sle.
 - 2. Leviton Manufacturing Company, Inc: www.leviton.com/#sle.
 - 3. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us/#sle.
- B. Wall Switches - General Requirements: AC only, quiet operating, general-use snap switches with silver alloy contacts, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 20 and where applicable, FS W-S-896; types as indicated on the drawings.
 - 1. Wiring Provisions: Terminal screws for side wiring with separate ground terminal screw.
- C. Standard Wall Switches: Commercial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.
- D. Lighted Wall Switches: Industrial specification grade, 20 A, 120/277 V with illuminated standard toggle type switch actuator and maintained contacts; illuminated with load off; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.
- E. Pilot Light Wall Switches: Industrial specification grade, 20 A, 120/277 V with red illuminated standard toggle type switch actuator and maintained contacts; illuminated with load on; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.
- F. Locking Wall Switches: Industrial specification grade, 20 A, 120/277 V with lever type keyed switch actuator and maintained contacts; switches keyed alike; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.

2.04 WALL DIMMERS

- A. Manufacturers:
 - 1. Leviton Manufacturing Company, Inc: www.leviton.com/#sle.
 - 2. Lutron Electronics Company, Inc; Maestro Series: www.lutron.com/#sle.

3. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us/#sle.
 4. Hubbell Incorporated: www.hubbell.com/#sle.
- B. Wall Dimmers - General Requirements: Solid-state with continuous full-range even control following square law dimming curve, integral radio frequency interference filtering, power failure preset memory, air gap switch accessible without removing wall plate, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1472; types and ratings suitable for load controlled as indicated on the drawings.
- C. Control: Slide control type with separate on/off switch.
- D. Power Rating, Unless Otherwise Indicated or Required to Control the Load Indicated on the Drawings:

2.05 FAN SPEED CONTROLLERS

- A. Description: 120 V AC, solid-state, full-range variable speed, slide control type with separate on/off switch, with integral radio frequency interference filtering, fan noise elimination circuitry, power failure preset memory, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 1917.
1. Current Rating: 1.5 A unless otherwise indicated or required to control the load indicated on the drawings.

2.06 RECEPTACLES

- A. Manufacturers:
1. Hubbell Incorporated: www.hubbell.com/#sle.
 2. Leviton Manufacturing Company, Inc: www.leviton.com/#sle.
 3. Pass & Seymour, a brand of Legrand North America, Inc: www.legrand.us/#sle.
- B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498; types as indicated on the drawings.
1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
 2. NEMA configurations specified are according to NEMA WD 6.
 3. Hospital Grade Receptacles: Listed as complying with UL 498 Supplement SD, with green dot hospital grade mark on device face.
- C. Convenience Receptacles:
1. Standard Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
 - a. Construction: Brass contacts and a steel strap
 2. Weather Resistant Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.
 3. Tamper Resistant Convenience Receptacles: Commercial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; single or duplex as indicated on the drawings.
- D. GFCI Receptacles:
1. GFCI Receptacles - General Requirements: Self-testing, with light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.
 2. Standard GFCI Receptacles: Commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
- E. USB Charging Devices:
1. USB Charging Devices - General Requirements: Listed as complying with UL 1310.
 2. USB Charging/Tamper Resistant Receptacle Combination Devices: Two-port (Type A) USB charging device and receptacle, commercial specification grade, duplex, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; rectangular decorator style.

2.07 WALL PLATES

- A. Wall Plates: Comply with UL 514D.
 - 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
 - 2. Size: Standard.
 - 3. Screws: Metal with slotted heads finished to match wall plate finish.
- B. Nylon Wall Plates: Smooth finish, high-impact thermoplastic.
- C. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.
- D. Galvanized Steel Wall Plates: Rounded corners and edges, with corrosion resistant screws.
- E. Weatherproof Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that floor boxes are adjusted properly.
- F. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- G. Verify that core drilled holes for poke-through assemblies are in proper locations.
- H. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of wiring devices provided under this section.
 - 1. Where multiple receptacles, wall switches, or wall dimmers are installed at the same location and at the same mounting height, gang devices together under a common wall plate.
 - 2. Locate wall switches on strike side of door with edge of wall plate 3 inches from edge of door frame. Where locations are indicated otherwise, notify Architect to obtain direction prior to proceeding with work.
 - 3. Locate receptacles for electric drinking fountains concealed behind drinking fountain according to manufacturer's instructions.
- C. Install wiring devices in accordance with manufacturer's instructions.
- D. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- E. Where required, connect wiring devices using pigtails not less than 6 inches long. Do not connect more than one conductor to wiring device terminals.
- F. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
- G. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- H. Provide GFCI receptacles with integral GFCI protection at each location indicated. Do not use feed-through wiring to protect downstream devices.

- I. Install wiring devices plumb and level with mounting yoke held rigidly in place.
- J. Install wall switches with OFF position down.
- K. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.
- L. Do not share neutral conductor on branch circuits utilizing wall dimmers.
- M. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- N. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.
- O. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.
- P. Identify wiring devices in accordance with Section 26 05 53.

3.03 FIELD QUALITY CONTROL

- A. Inspect each wiring device for damage and defects.
- B. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- C. Test each receptacle to verify operation and proper polarity.
- D. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- E. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.04 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.

3.05 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION

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**SECTION 26 28 16.13
ENCLOSED CIRCUIT BREAKERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Enclosed circuit breakers.

1.02 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- E. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- F. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for circuit breakers, enclosures, and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of enclosed circuit breakers and adjacent equipment with all required clearances indicated.

1.05 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB/GE: www.geindustrial.com/#sle.

- B. Eaton Corporation: www.eaton.com/#sle.
- C. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.
- D. Source Limitations: Furnish enclosed circuit breakers and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 ENCLOSED CIRCUIT BREAKERS

- A. Description: Units consisting of molded case circuit breakers individually mounted in enclosures.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature: Between 23 degrees F and 104 degrees F.
- D. Short Circuit Current Rating:
 - 1. Provide enclosed circuit breakers with listed short circuit current rating not less than the available fault current at the installed location indicated on the drawings.
- E. Conductor Terminations: Suitable for use with the conductors to be installed.
- F. Provide thermal magnetic circuit breakers unless otherwise indicated.
- G. Provide solidly bonded equipment ground bus in each enclosed circuit breaker, with a suitable lug for terminating each equipment grounding conductor.
- H. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
- I. Provide externally operable handle with means for locking in the OFF position.

2.03 MOLDED CASE CIRCUIT BREAKERS

- A. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
- B. Interrupting Capacity:
 - 1. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
 - 2. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
- C. Conductor Terminations:
 - 1. Provide mechanical lugs unless otherwise indicated.
 - 2. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
- D. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
- E. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings of the enclosed circuit breakers are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive enclosed circuit breakers.

- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Install enclosed circuit breakers plumb.
- F. Install flush-mounted enclosed circuit breakers so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- G. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed circuit breakers such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- H. Provide grounding and bonding in accordance with Section 26 05 26.
- I. Where installed on either side of a VFD, provide one normally open and one normally closed auxillary contacts for disconnect switches for all fans and pumps.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Correct deficiencies and replace damaged or defective enclosed circuit breakers.

3.04 ADJUSTING

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

3.05 CLEANING

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

END OF SECTION

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**SECTION 26 28 16.16
ENCLOSED SWITCHES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Enclosed safety switches.

1.02 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum) 2013.
- D. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations Current Edition, Including All Revisions.
- F. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations Current Edition, Including All Revisions.
- G. UL 98 - Enclosed and Dead-Front Switches Current Edition, Including All Revisions.
- H. UL 869A - Reference Standard for Service Equipment Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 4. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- B. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Include dimensioned plan and elevation views of enclosed switches and adjacent equipment with all required clearances indicated.
- C. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB/GE: www.geindustrial.com/#sle.
- B. Eaton Corporation: www.eaton.com/#sle.
- C. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.
- D. Source Limitations: Furnish enclosed switches and associated components produced by the same manufacturer as the other electrical distribution equipment used for this project and obtained from a single supplier.

2.02 ENCLOSED SAFETY SWITCHES

- A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet.
 - 2. Ambient Temperature: Between -22 degrees F and 104 degrees F.
- D. Horsepower Rating: Suitable for connected load.
- E. Voltage Rating: Suitable for circuit voltage.
- F. Short Circuit Current Rating:
 - 1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
 - 2. Minimum Ratings:
 - a. Heavy Duty Single Throw Switches Protected by Class R, Class J, or Class L Fuses: 200,000 rms symmetrical amperes.
- G. Enclosed Safety Switches Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.
- H. Provide with switch blade contact position that is visible when the cover is open.
- I. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
 - 1. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.
- J. Conductor Terminations: Suitable for use with the conductors to be installed.
- K. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.
- L. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- M. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1.
 - b. Outdoor Locations: Type 3R.
 - 2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
- N. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- O. Heavy Duty Switches:
 - 1. Comply with NEMA KS 1.

2. Conductor Terminations:
 - a. Provide mechanical lugs unless otherwise indicated.
 - b. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
3. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Install enclosed switches plumb.
- F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.
- G. Provide grounding and bonding in accordance with Section 26 05 26.
- H. Provide fuses complying with Section 26 28 13 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- I. Where installed on either side of a VFD, provide one normally open and one normally closed auxillary contacts for disconnect switches for all fans and pumps.

3.03 FIELD QUALITY CONTROL

- A. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.04 ADJUSTING

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

3.05 CLEANING

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

END OF SECTION

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**SECTION 26 29 13
ENCLOSED CONTROLLERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Enclosed NEMA controllers for low-voltage (600 V and less) applications:
 - 1. Magnetic motor starters.
 - 2. Manual motor starters.
- B. Overcurrent protective devices for motor controllers, including overload relays.
- C. Control accessories:
 - 1. Auxiliary contacts.
 - 2. Pilot devices.
 - 3. Control and timing relays.
 - 4. Control power transformers.

1.02 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts 2008 (Reaffirmed 2020).
- D. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices 2017.
- E. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum) 2013.
- F. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- G. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 98 - Enclosed and Dead-Front Switches Current Edition, Including All Revisions.
- I. UL 60947-1 - Low-Voltage Switchgear and Controlgear - Part 1: General Rules Current Edition, Including All Revisions.
- J. UL 60947-4-1 - Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-starters - Electromechanical Contactors and Motor-starters Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 2. Coordinate the work to provide motor controllers and associated overload relays suitable for use with the actual motors to be installed.
 - 3. Coordinate the work to provide controllers and associated wiring suitable for interface with control devices to be installed.
 - 4. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 5. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 6. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.04 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. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB/GE: www.geindustrial.com/#sle.
- B. Eaton Corporation: www.eaton.com/#sle.
- C. Rockwell Automation, Inc; Allen-Bradley Products: ab.rockwellautomation.com/#sle.
- D. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.
- E. Source Limitations: Furnish enclosed motor controllers and associated components produced by a single manufacturer and obtained from a single supplier.
 - 1. Motor-starting switches without overload protection may be produced by the same manufacturer as the wiring devices used for this project.

2.02 ENCLOSED CONTROLLERS

- A. Provide enclosed controller assemblies consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Description: Enclosed controllers complying with NEMA ICS 2, and listed and labeled as complying with UL 60947-1 and UL 60947-4-1; ratings, configurations and features as indicated on the drawings.
- D. Service Conditions:
 - 1. Provide controllers and associated components suitable for operation under the following service conditions without derating:
 - a. Altitude:
 - 1) Class 1 Km Equipment (devices utilizing power semiconductors, e.g. variable frequency controllers): Less than 3,300 feet.
 - 2) Class 2 Km Equipment (electromagnetic and manual devices): Less than 6,600 feet.
 - b. Ambient Temperature: Between 32 degrees F and 104 degrees F.
- E. Short Circuit Current Rating:
 - 1. Provide controllers with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.
- F. Conductor Terminations: Suitable for use with the conductors to be installed.
- G. Enclosures:
 - 1. Comply with NEMA ICS 6.
 - 2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:

- a. Indoor Clean, Dry Locations: Type 1 or Type 12.
 - b. Outdoor Locations: Type 3R or Type 4.
- 3. Finish: Manufacturer's standard unless otherwise indicated.
- H. Instrument Transformers:
 - 1. Comply with IEEE C57.13.
 - 2. Select suitable ratio, burden, and accuracy as required for connected devices.
 - 3. Current Transformers: Connect secondaries to shorting terminal blocks.
 - 4. Potential Transformers: Include primary and secondary fuses with disconnecting means.
- I. Magnetic Motor Starters: Combination type unless otherwise indicated.
 - 1. Combination Magnetic Motor Starters: NEMA ICS 2, Class A combination motor controllers with magnetic contactor(s), externally operable disconnect and overload relay(s).
 - 2. Configuration: Full-voltage non-reversing unless otherwise indicated.
 - 3. Disconnects: Disconnect switch type.
 - a. Disconnect Switches: Fusible type unless otherwise indicated.
 - b. Provide externally operable handle with means for locking in the OFF position. Provide safety interlock to prevent opening the cover with the disconnect in the ON position with capability of overriding interlock for testing purposes.
 - c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
 - 4. Overload Relays: Bimetallic thermal type unless otherwise indicated.
 - 5. Pilot Devices Required:
 - a. Furnish local pilot devices for each unit as specified below unless otherwise indicated on drawings.
 - b. Single-Speed, Non-Reversing Starters:
 - 1) Pushbuttons: START-STOP.
 - 2) Selector Switches: HAND/OFF/AUTO.
 - 3) Indicating Lights: Red ON, Green OFF.
- J. Manual Motor Starters:
 - 1. Description: NEMA ICS 2, Class A manually-operated motor controllers with overload relay(s).
 - 2. Configuration: Non-reversing unless otherwise indicated.
 - 3. Fractional-Horsepower Manual Motor Starters:
 - a. Furnish with toggle operator.
 - b. Overload Relays: Bimetallic or melting alloy thermal type.
 - c. Provide means for locking operator in the OFF position.
 - 4. Integral-Horsepower Manual Motor Starters:
 - a. Furnish with toggle or pushbutton operator.
 - b. Overload Relays: Bimetallic or melting alloy thermal type.
 - c. Provide means for locking operator in the OFF position.

2.03 OVERCURRENT PROTECTIVE DEVICES

- A. Overload Relays:
 - 1. Provide overload relays and, where applicable, associated current elements/heaters, selected according to actual installed motor nameplate data, in accordance with manufacturer's recommendations and NFPA 70; include consideration for motor service factor and ambient temperature correction, where applicable.
 - 2. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
 - 3. Trip-free operation.
 - 4. Visible trip indication.
 - 5. Resettable.
 - a. Employ manual reset unless otherwise indicated.
 - b. Do not employ automatic reset with two-wire control.
 - 6. Bimetallic Thermal Overload Relays:

- a. Interchangeable current elements/heaters.
 - b. Adjustable trip; plus/minus 10 percent of nominal, minimum.
 - c. Trip test function.
- B. Fusible Disconnect Switches:
- 1. Description: Quick-make, quick-break, dead-front fusible switch units complying with NEMA KS 1, and listed and labeled as complying with UL 98; ratings, configurations, and features as indicated on the drawings.
 - 2. Fuse Clips: As required to accept indicated fuses.
 - 3. Provide externally operable handle with means for locking in the OFF position. Provide means for locking switch cover in the closed position. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

2.04 CONTROL ACCESSORIES

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

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install controllers in accordance with NECA 1 (general workmanship).
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Install enclosed controllers plumb and level.
- F. Provide grounding and bonding in accordance with Section 26 05 26.
- G. Install all field-installed devices, components, and accessories.
- H. Provide fuses complying with Section 26 28 13 for fusible switches as indicated.
- I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

- J. Set field-adjustable controllers and associated components according to installed motor requirements, in accordance with manufacturer's recommendations and NFPA 70.
- K. Set field-adjustable circuit breaker tripping function settings as indicated.

3.03 FIELD QUALITY CONTROL

- A. Motor Starters: Perform inspections and tests listed in NETA ATS, Section 7.16.1.1. Tests listed as optional are not required.
- B. Fusible Switches: Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.
- C. Correct deficiencies and replace damaged or defective enclosed controllers or associated components.

3.04 ADJUSTING

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

3.05 CLEANING

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

3.06 CLOSEOUT ACTIVITIES

- A. 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 enclosed 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.

3.07 PROTECTION

- A. Protect installed enclosed controllers from subsequent construction operations.

END OF SECTION

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SECTION 26 32 13 ENGINE GENERATORS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Packaged engine generator system and associated components and accessories:
 - 1. Engine and engine accessory equipment.
 - 2. Alternator (generator).
 - 3. Generator set control system.
 - 4. Generator set enclosure.

1.02 REFERENCE STANDARDS

- A. ASTM D975 - Standard Specification for Diesel Fuel 2022a.
- B. NECA/EGSA 404 - Standard for Installing Generator Sets 2014.
- C. NEMA MG 1 - Motors and Generators 2021.
- D. NFPA 30 - Flammable and Combustible Liquids Code 2021, with Amendment.
- E. NFPA 37 - Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines 2021.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. NFPA 99 - Health Care Facilities Code 2021, with Amendment.
- H. NFPA 110 - Standard for Emergency and Standby Power Systems 2022.
- I. UL 142 - Steel Aboveground Tanks for Flammable and Combustible Liquids Current Edition, Including All Revisions.
- J. UL 1236 - Battery Chargers for Charging Engine-Starter Batteries Current Edition, Including All Revisions.
- K. UL 2200 - Stationary Engine Generator Assemblies Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate compatibility of generator sets to be installed with work provided under other sections or by others.
 - a. Transfer Switches: See Section 26 36 00.
 - 2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment or other potential obstructions within the spaces dedicated for engine generator system.
 - 3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 4. Coordinate the work to provide electrical circuits suitable for the power requirements of the actual auxiliary equipment and accessories to be installed.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week before starting work of this section; require attendance of all affected installers.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features. Include alternator starting capabilities, engine fuel consumption rates, and cooling, combustion air, and exhaust requirements.
- B. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.

- C. Specification Compliance Review
- D. Derating Calculations: Indicate ratings adjusted for applicable service conditions.
- E. Fuel Storage Tank Calculations: Indicate maximum running time for generator set configuration provided.
- F. Source quality control test reports.
- G. Manufacturer's detailed field testing procedures.
- H. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- I. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- J. Maintenance contracts.

1.05 QUALITY ASSURANCE

- A. Comply with the following:
 - 1. NFPA 70 (National Electrical Code).
 - 2. NFPA 37 (Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines).
 - 3. NFPA 30 (Flammable and Combustible Liquids Code).
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
 - 1. Authorized service facilities located within 200 miles of project site.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store generator sets in accordance with manufacturer's instructions and NECA/EGSA 404.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to generator set components, enclosure, and finish.

1.07 FIELD CONDITIONS

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

1.08 WARRANTY

- A. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Packaged Engine Generator Set - Other Acceptable Manufacturers:
 - 1. Caterpillar Inc: www.cat.com/#sle.
 - 2. Cummins Power Generation Inc: www.cumminspower.com/#sle.
 - 3. Generac Power Systems: www.generac.com/industrial/#sle. Generac Power Systems: www.generac.com/industrial/#sle. Generac Power Systems: www.generac.com/industrial/#sle.
 - 4. Kohler Co: www.kohlerpower.com/#sle.

2.02 PACKAGED ENGINE GENERATOR SYSTEM

- A. Provide new engine generator system consisting of all required equipment, sensors, conduit, boxes, wiring, piping, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. System Description:
 - 1. Application: Emergency/standby.
 - 2. Configuration: Single packaged engine generator set operated independently (not in parallel).
 - 3. Total System Power Rating: As indicated on drawings, standby.
- D. Packaged Engine Generator Set:
 - 1. Type: Diesel (compression ignition).
 - 2. Voltage: As indicated on drawings.
- E. Generator Set General Requirements:
 - 1. Prototype tested in accordance with NFPA 110 for Level 1 systems.
 - 2. Factory-assembled, with components mounted on suitable base.
 - 3. List and label engine generator assembly as complying with UL 2200.
 - 4. Power Factor: Unless otherwise indicated, specified power ratings are at 0.8 power factor for three phase voltages and 1.0 power factor for single phase voltages.
 - 5. Provide suitable guards to protect personnel from accidental contact with rotating parts, hot piping, and other potential sources of injury.
- F. Service Conditions: Provide engine generator system and associated components suitable for operation under the service conditions at the installed location.
 - 1. Altitude: 1000 feet.
- G. Starting and Load Acceptance Requirements:
 - 1. Cranking Method: Cycle cranking complying with NFPA 110 (15 second crank period, followed by 15 second rest period, with cranking limiter time-out after 3 cycles), unless otherwise required.
 - 2. Cranking Limiter Time-Out: If generator set fails to start after specified cranking period, indicate overcrank alarm condition and lock-out generator set from further cranking until manually reset.
 - 3. Start Time: Capable of starting and achieving conditions necessary for load acceptance within 10 seconds (NFPA 110, Type 10).
 - 4. Maximum Load Step: Supports 100 percent of rated load in one step.
- H. Exhaust Emissions Requirements:
 - 1. Comply with federal (EPA), state, and local regulations applicable at the time of commissioning; include factory emissions certification with submittals.
 - 2. Do not make modifications affecting generator set factory emissions certification without approval of manufacturer and Engineer. Where such modifications are made, provide field emissions testing as necessary for certification.

2.03 ENGINE AND ENGINE ACCESSORY EQUIPMENT

- A. Provide engine with adequate horsepower to achieve specified power output at rated speed, accounting for alternator efficiency and parasitic loads.
- B. Engine Fuel System - Diesel (Compression Ignition):
 - 1. Fuel Source: Diesel, ASTM D975 No. 2-D or approved cold weather diesel blends.
 - 2. Fuel Storage: Sub-base fuel tank.
 - 3. Engine Fuel Supply: Provide engine-driven, positive displacement fuel pump with replaceable fuel filter(s), water separator, check valve to secure prime, manual fuel priming pump, and relief-bypass valve. Provide fuel cooler where recommended by manufacturer.
 - 4. Engine Fuel Connections: Provide suitable, approved flexible fuel lines for coupling engine to fuel source.

5. Sub-Base Fuel Tank:
 - a. Provide sub-base mounted, double-wall fuel tank with secondary containment; listed and labeled as complying with UL 142.
 - b. Tank Capacity: Size for minimum of 24 hours of continuous engine generator operation at 100 percent rated load, but not larger than permissible by applicable codes.
 - c. Features:
 - 1) Direct reading fuel level gauge.
 - 2) Normal atmospheric vent.
 - 3) Emergency pressure relief vent.
 - 4) Fuel fill opening with lockable cap.
 - 5) Dedicated electrical conduit stub-up area.
 - 6) Low fuel level switch.
 - 7) Leak detection switch; located within secondary containment interstitial space for detection of primary tank fuel leak.
- C. Engine Starting System:
 1. System Type: Electric, with DC solenoid-activated starting motor(s).
 2. Battery(s):
 - a. Battery Type: Lead-acid.
 - b. Battery Capacity: Size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature; capable of providing cranking through two complete periods of cranking limiter time-outs without recharging.
 - c. Provide battery rack, cables, and connectors suitable for the supplied battery(s); size battery cables according to manufacturer's recommendations for cable length to be installed.
 3. Battery-Charging Alternator: Engine-driven, with integral solid-state voltage regulation.
 4. Battery Charger:
 - a. Provide dual rate battery charger with automatic float and equalize charging modes and minimum rating of 10 amps; suitable for maintaining the supplied battery(s) at full charge without manual intervention.
 - b. Capable of returning supplied battery(s) from fully discharged to fully charged condition within 24 hours, as required by NFPA 110 for Level 1 applications while carrying normal loads.
 - c. Recognized as complying with UL 1236.
 - d. Furnished with integral overcurrent protection; current limited to protect charger during engine cranking; reverse polarity protection.
 - e. Provide integral DC output ammeter and voltmeter with five percent accuracy.
 - f. Provide alarm output contacts as necessary for alarm indications.
- D. Engine Speed Control System (Governor):
 1. Single Engine Generator Sets (Not Operated in Parallel): Provide electronic isochronous governor for controlling engine speed/alternator frequency.
 2. Frequency Regulation, Electronic Isochronous Governors: No change in frequency from no load to full load; plus/minus 0.25 percent at steady state.
- E. Engine Lubrication System:
 1. System Type: Full pressure, with engine-driven, positive displacement lubrication oil pump, replaceable full-flow oil filter(s), and dip-stick for oil level indication. Provide oil cooler where recommended by manufacturer.
- F. Engine Cooling System:
 1. System Type: Closed-loop, liquid-cooled, with unit-mounted radiator/fan and engine-driven coolant pump; suitable for providing adequate cooling while operating at full load under worst case ambient temperature.
 2. Fan Guard: Provide suitable guard to protect personnel from accidental contact with fan.

3. Coolant Heater: Provide thermostatically controlled coolant heater to improve starting under cold ambient conditions; size according to manufacturer's recommendations for achieving starting and load acceptance requirements under worst case ambient temperature.
- G. Engine Air Intake and Exhaust System:
 1. Air Intake Filtration: Provide engine-mounted, replaceable, dry element filter.
 2. Engine Exhaust Connection: Provide suitable, approved flexible connector for coupling engine to exhaust system.
 3. Exhaust Silencer: Provide critical grade or better exhaust silencer; select according to manufacturer's recommendations to meet sound performance requirements, where specified.

2.04 ALTERNATOR (GENERATOR)

- A. Alternator: 4-pole, 1800 rpm (60 Hz output) revolving field, synchronous generator complying with NEMA MG 1; connected to engine with flexible coupling; voltage output configuration as indicated, with reconnectable leads for 3 phase alternators.
- B. Exciter:
 1. Exciter Type: Brushless; provide permanent magnet generator (PMG) excitation system; self-excited (shunt) systems are not permitted.
 2. PMG Excitation Short-Circuit Current Support: Capable of sustaining 300 percent of rated output current for 10 seconds.
- C. Temperature Rise: Comply with UL 2200.
- D. Insulation System: NEMA MG 1, Class H; suitable for alternator temperature rise.
- E. Enclosure: NEMA MG 1, drip-proof.
- F. Total Harmonic Distortion: Not greater than five percent.

2.05 GENERATOR SET CONTROL SYSTEM

- A. Provide microprocessor-based control system for automatic control, monitoring, and protection of generator set. Include sensors, wiring, and connections necessary for functions/indications specified.
- B. Control Panel:
 1. Control Panel Mounting: Unit-mounted unless otherwise indicated; vibration isolated.
 2. Generator Set Control Functions:
 - a. Automatic Mode: Initiates generator set start/shutdown upon receiving corresponding signal from remote device (e.g. automatic transfer switch).
 - b. Manual Mode: Initiates generator set start/shutdown upon direction from operator.
 - c. Reset Mode: Clears all faults, allowing generator set restart after a shutdown.
 - d. Emergency Stop: Immediately shuts down generator set (without time delay) and prevents automatic restarting until manually reset.
 - e. Cycle Cranking: Programmable crank time, rest time, and number of cycles.
 - f. Time Delay: Programmable for shutdown (engine cooldown) and start (engine warmup).
 - g. Voltage Adjustment: Adjustable through range of plus/minus 5 percent.
3. Generator Set Status Indications:
 - a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
 - b. Current (Amps): For each phase.
 - c. Frequency (Hz).
 - d. Real power (W/kW).
 - e. Reactive power (VAR/kVAR).
 - f. Apparent power (VA/kVA).
 - g. Power factor.
 - h. Duty Level: Actual load as percentage of rated power.
 - i. Engine speed (RPM).
 - j. Battery voltage (Volts DC).

- k. Engine oil pressure.
- l. Engine coolant temperature.
- m. Engine run time.
- n. Generator powering load (position signal from transfer switch).
- 4. Generator Set Protection and Warning/Shutdown Indications:
 - a. Comply with NFPA 110; configurable for NFPA 110 Level 1 or Level 2, or NFPA 99 systems including but not limited to the following protections/indications:
 - 1) Overcrank (shutdown).
 - 2) Low coolant temperature (warning).
 - 3) High coolant temperature (warning).
 - 4) High coolant temperature (shutdown).
 - 5) Low oil pressure (shutdown).
 - 6) Overspeed (shutdown).
 - 7) Low fuel level (warning).
 - 8) Low coolant level (warning/shutdown).
 - 9) Generator control not in automatic mode (warning).
 - 10) High battery voltage (warning).
 - 11) Low cranking voltage (warning).
 - 12) Low battery voltage (warning).
 - 13) Battery charger failure (warning).
 - b. In addition to NFPA 110 requirements, provide the following protections/indications:
 - 1) High AC voltage (shutdown).
 - 2) Low AC voltage (shutdown).
 - 3) High frequency (shutdown).
 - 4) Low frequency (shutdown).
 - 5) Overcurrent (shutdown).
 - 6) Fuel tank leak (warning), where applicable.
 - c. Provide contacts for local and remote common alarm.
 - d. Provide lamp test function that illuminates all indicator lamps.
- 5. Other Control Panel Features:
 - a. Event log.
 - b. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
 - c. Remote monitoring capability via PC.
- C. Remote Annunciator:
 - 1. Remote Annunciator Mounting: Wall-mounted; Provide flush-mounted annunciator for finished areas and surface-mounted annunciator for non-finished areas unless otherwise indicated.
 - 2. Generator Set Status Indications:
 - a. Generator powering load (via position signal from transfer switch).
 - b. Communication functional.
 - 3. Generator Set Warning/Shutdown Indications:
 - a. Comply with NFPA 110; configurable for NFPA 110 Level 1 or Level 2, or NFPA 99 systems including but not limited to the following indications:
 - 1) Overcrank (shutdown).
 - 2) Low coolant temperature (warning).
 - 3) High coolant temperature (warning).
 - 4) High coolant temperature (shutdown).
 - 5) Low oil pressure (shutdown).
 - 6) Overspeed (shutdown).
 - 7) Low fuel level (warning).
 - 8) Low coolant level (warning/shutdown).
 - 9) Generator control not in automatic mode (warning).
 - 10) High battery voltage (warning).

- 11) Low cranking voltage (warning).
- 12) Low battery voltage (warning).
- 13) Battery charger failure (warning).
- b. Provide audible alarm with silence function.
- c. Provide lamp test function that illuminates all indicator lamps.
- D. Remote Emergency Stop: Provide approved red, mushroom style remote emergency stop button where indicated or required by authorities having jurisdiction.

2.06 GENERATOR SET ENCLOSURE

- A. Enclosure Type: Sound attenuating, weather protective.
- B. Enclosure Material: Steel or aluminum.
- C. Hardware Material: Stainless steel.
- D. Color: Manufacturer's standard.
- E. Access Doors: Lockable, with all locks keyed alike.
- F. Openings: Designed to prevent bird/rodent entry.
- G. External Drains: Extend oil and coolant drain lines to exterior of enclosure for maintenance service.
- H. Exhaust Silencers: Where exhaust silencers are mounted within enclosure in main engine compartment, insulate silencer to minimize heat dissipation as necessary for operation at rated load under worst case ambient temperature.

2.07 SOURCE QUALITY CONTROL

- A. Perform production tests on generator sets at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.
- B. Generator Set production testing to include, at a minimum:
 - 1. Operation at rated load and rated power factor.
 - 2. Single step load pick-up.
 - 3. Transient and steady state voltage and frequency performance.
 - 4. Operation of safety shutdowns.
- C. Diesel Fuel Storage Tanks: Perform pressurized leak test prior to shipment.

2.08 TEMPORARY GENERATOR CONNECTION CABINET

- A. Ratings
 - 1. Voltage: Match voltage and phase of the generator.
 - 2. Short Circuit: Rating greater than available fault current of the generator or as indicated on the drawings.
 - 3. Ampacity: Greater than or equal to the full load capacity of the generator.
- B. Components
 - 1. One compartment shall contain mechanical terminations for conductors.
 - 2. One compartment with hinge access shall contain cam lock connectors for each phase, neutral, and ground of generator system specified.
 - 3. Connectors shall be of correct size for ampacity of generator.
- C. Enclosure
 - 1. Steel Enclosure with NEMA 3R rating. Powder coated with manufacturer standard color.
 - 2. Hinged lockable cover on cam lock compartment.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of generator sets and auxiliary equipment are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.

- D. Verify that mounting surfaces are ready to receive equipment.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install generator sets and associated accessories in accordance with NECA/EGSA 404.
- C. Arrange equipment to provide minimum clearances and required maintenance access.
- D. Unless otherwise indicated, mount generator set on properly sized, minimum 6 inch high concrete pad constructed in accordance with Section 03 30 00.
- E. Provide required support and attachment in accordance with Section 26 05 29.
- F. Use manufacturer's recommended oil and coolant, suitable for the worst case ambient temperatures.
- G. Provide diesel fuel piping and venting in accordance with Section 23 11 13, where not factory installed.
- H. Provide engine exhaust piping in accordance with Section 23 51 00, where not factory installed.
 - 1. Include piping expansion joints, piping insulation, thimble, condensation trap/drain, rain cap, hangers/supports, etc. as indicated or as required.
 - 2. Do not exceed manufacturer's maximum back pressure requirements.
- I. Install exhaust silencer in accordance with manufacturers installation instructions, where not factory installed.
- J. Provide grounding and bonding in accordance with Section 26 05 26.
- K. Identify system wiring and components in accordance with Section 26 05 53.

3.03 FIELD QUALITY CONTROL

- A. Provide services of a manufacturer's authorized representative to prepare and start systems and perform inspection and testing. Include manufacturer's detailed testing procedures and field reports with submittals.
- B. Notify Owner and Architect at least two weeks prior to scheduled inspections and tests.
- C. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- D. Provide all equipment, tools, and supplies required to accomplish inspection and testing, including load bank and fuel.
- E. Preliminary inspection and testing to include, at a minimum:
 - 1. Inspect each system component for damage and defects.
 - 2. Verify tightness of mechanical and electrical connections are according to manufacturer's recommended torque settings.
 - 3. Check for proper oil and coolant levels.
- F. Prepare and start system in accordance with manufacturer's instructions.
- G. Perform acceptance test in accordance with NFPA 110.
- H. Inspection and testing to include, at a minimum:
 - 1. Verify compliance with starting and load acceptance requirements.
 - 2. Verify voltage and frequency; make required adjustments as necessary.
 - 3. Verify phase sequence.
 - 4. Verify control system operation, including safety shutdowns.
 - 5. Verify operation of auxiliary equipment and accessories (e.g. battery charger, heaters, etc.).
 - 6. Perform load tests in accordance with NFPA 110 (1.5 hour building load test followed by 2 hour full load test).
- I. Provide field emissions testing where necessary for certification.

- J. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.

3.04 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.05 CLOSEOUT ACTIVITIES

- A. Demonstration: Demonstrate proper operation of system to Owner, and correct deficiencies or make adjustments as directed.
- B. Training: Train Owner's personnel on operation, adjustment, and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of four hours of training.
 - 3. Instructor: Manufacturer's authorized representative.
 - 4. Location: At project site.
- C. After successful acceptance test and just prior to Substantial Completion, replace air, oil, and fuel filters and fill fuel storage tank.

3.06 PROTECTION

- A. Protect installed engine generator system from subsequent construction operations.

3.07 MAINTENANCE

- A. Provide to Owner a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of engine generator system for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.
- B. Provide trouble call-back service upon notification by Owner:
 - 1. Provide on-site response within 4 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.
- C. Maintain an on-site log 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.

END OF SECTION

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SECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Charger/rectifier units.
- B. Inverter unit.
- C. Batteries.

1.02 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. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 SUBMITTALS

- A. 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.
- B. Product Data: Provide catalog sheets and technical data sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements.
- C. Specification Compliance Review.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product. Include equipment installation outline, connection diagram for external cabling, internal wiring diagram, and written instruction for installation.

1.04 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.05 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.

1.06 FIELD CONDITIONS

- A. Do not store or install unless temperature is maintained between 32 degrees F and 104 degrees F, at a relative humidity less than 95 percent (non-condensing).

1.07 WARRANTY

- A. Provide five year warranty including coverage for batteries.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Uninterruptible Power Supply (UPS) System:
 - 1. ABB/GE: www.geindustrial.com/#sle.
 - 2. Eaton Corporation: www.eaton.com/#sle.
 - 3. Schneider Electric; APC Products: www.schneider-electric.us/#sle.

4. Toshiba Corporation: www.toshiba.com/#sle.
5. Vertiv.

2.02 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. Battery.
 2. Rectifier/charger to maintain battery charge and to provide input to inverter when utility power is available.
 3. Static switch to transfer load automatically and without disturbance between inverter and utility power.
 4. Manual switch to bypass static switch for maintenance.
- C. Design Standards: IEEE 519 and NEMA PE 1.

2.03 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 [] hours.
- C. Input Current Limit: Adjustable to maximum of 125 percent of that required to operate at full load with battery bank on float charge.
- D. Three-phase Overload Ratings:
 1. 150 percent for 10 seconds.
- E. Output Current Limit: 150 percent of rated output current.

2.04 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.

2.05 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.
- C. Cabinet finish: Primed and painted inside and outside with suitable semi-gloss enamel.

2.06 BATTERY

- A. Storage Battery: Lead calcium 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.

2.07 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 output circuit breaker.
 6. Static switch bypass circuit breaker.
 7. Controls for maintenance bypass switch.
- B. Indicators:

1. Load connected to utility.
- C. Meters: Use 1 percent accuracy meters to indicate the following:
 1. Rectifier/charger DC voltage and current.
 2. Load AC current.
- D. Wall-mounted Alarm Panel: Surface mounted annunciator panel with the following monitoring and alarm functions:
 1. Utility power available.
 2. Inverter output available.
 3. Load connected to inverter output.
 4. Static transfer switch inhibited (alarm).
 5. High/low DC voltage (alarm).
 6. Overtemperature (alarm).
 7. Inverter output overload (alarm).
 8. Audible alarm (sounds when any of the above alarm conditions occur).
 9. Alarm/indicator silence/test switch.

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 FIELD QUALITY CONTROL

- A. Provide the services of the manufacturer's field technician to supervise adjustments, final connections, and system testing.
- B. Verify specification performance criteria.
- C. Measure battery discharge and recharge times.
- D. Simulate fault in each system component and utility power.

3.03 CLOSEOUT ACTIVITIES

- A. Demonstrate operation uninterruptible power supply by simulating an outage.
- B. Training: Provide 2 hours of instruction each for two persons.
 1. Instruction to be conducted at project site with manufacturer's representative.

3.04 MAINTENANCE

- A. Provide a separate maintenance contract for specified maintenance service.
- B. Provide service and maintenance of uninterruptible power supply for one year from Date of Substantial Completion.
- C. Include all costs, including labor, parts, and travel.

END OF SECTION

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**SECTION 26 36 00
TRANSFER SWITCHES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Transfer switches for low-voltage (600 V and less) applications and associated accessories:
 - 1. Automatic transfer switches.

1.02 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NEMA ICS 10 Part 1 - Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment 2020.
- D. NETA ATS - Standard For Acceptance Testing Specifications For Electrical Power Equipment And Systems 2021.
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NFPA 99 - Health Care Facilities Code 2021, with Amendment.
- G. NFPA 110 - Standard for Emergency and Standby Power Systems 2022.
- H. UL 1008 - Transfer Switch Equipment Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate compatibility of transfer switches to be installed with work provided under other sections or by others.
 - a. Engine Generators: See Section 26 32 13.
 - 2. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by NFPA 70.
 - 3. Coordinate arrangement of equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 4. Coordinate the work with placement of supports, anchors, etc. required for mounting.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meeting: Convene one week before starting work of this section; require attendance of all affected installers.
- C. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.

1.04 SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product, including ratings, configurations, dimensions, finishes, weights, service condition requirements, and installed features.
- B. Shop Drawings: Include dimensioned plan views and sections indicating locations of system components, required clearances, and field connection locations. Include system interconnection schematic diagrams showing all factory and field connections.
- C. Specification Compliance Review
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and operation of product.
- E. Source quality control test reports.

- F. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
 - 1. Include contact information for entity that will be providing contract maintenance and trouble call-back service.
- G. Maintenance contracts.

1.05 QUALITY ASSURANCE

- A. Comply with the following:
 - 1. NFPA 70 (National Electrical Code).
 - 2. NFPA 110 (Standard for Emergency and Standby Power Systems); meet requirements for Level 1 system.
 - 3. NFPA 99 (Health Care Facilities Code).
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
 - 1. Authorized service facilities located within 200 miles of project site.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store transfer switches in accordance with manufacturer's instructions.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's instructions to avoid damage to transfer switch components, enclosure, and finish.

1.07 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Transfer Switches:
 - 1. ABB/GE: www.geindustrial.com/#sle.
 - 2. ASCO Power Technologies: www.ascopower.com/#sle.
 - 3. Cummins: www.cummins.com/#sle
 - 4. Eaton Corporation: www.eaton.com/#sle.
- B. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.
- C. Source Limitations: Furnish transfer switches and accessories produced by a single manufacturer and obtained from a single supplier.

2.02 TRANSFER SWITCHES

- A. Provide complete power transfer system consisting of all required equipment, conduit, boxes, wiring, supports, accessories, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Applications:
 - 1. Utilize open transition transfer unless otherwise indicated or required.

2. For transfer of highly inductive loads (e.g. large motors and transformers), utilize open transition transfer with in-phase monitor or delayed transition transfer.
3. Provide signal before transfer contacts for transfer switches serving elevators.
- D. Construction Type: Only "contactor type" (open contact) transfer switches are acceptable. Do not use "breaker type" (enclosed contact) transfer switches.
- E. Comply with NEMA ICS 10 Part 1, and list and label as complying with UL 1008 for the classification of the intended application (e.g. emergency, optional standby).
- F. Do not use double throw safety switches or other equipment not specifically designed for power transfer applications and listed as transfer switch equipment.
- G. Load Classification: Classified for total system load (any combination of motor, electric discharge lamp, resistive, and tungsten lamp loads with tungsten lamp loads not exceeding 30 percent of the continuous current rating) unless otherwise indicated or required.
- H. Switching Methods:
 1. Open Transition:
 - a. Provide break-before-make transfer without a neutral position that is not connected to either source, and with interlocks to prevent simultaneous connection of the load to both sources.
 - b. Where in-phase transfer is indicated, utilize in-phase monitor to initiate transfer when phase angle difference between sources is near zero to limit in-rush currents.
 2. Delayed Transition:
 - a. Provide break-before-make transfer with programmable time delay in a neutral position not connected to either source, and with interlocks to prevent simultaneous connection of the load to both sources.
 3. Obtain control power for transfer operation from line side of source to which the load is to be transferred.
- I. Service Conditions: Provide transfer switches suitable for continuous operation at indicated ratings under the service conditions at the installed location.
- J. Enclosures:
 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Indoor Clean, Dry Locations: Type 1 or Type 12.
 - b. Outdoor Locations: Type 3R or Type 4.
 2. Finish: Manufacturer's standard unless otherwise indicated.
- K. Short Circuit Current Rating:
 1. Withstand and Closing Rating: Provide transfer switches, when protected by the supply side overcurrent protective devices to be installed, with listed withstand and closing rating not less than the available fault current at the installed location as indicated on the drawings.
- L. Automatic Transfer Switches:
 1. Description: Transfer switches with automatically initiated transfer between sources; electrically operated and mechanically held.
 2. Control Functions:
 - a. Automatic mode.
 - b. Test Mode: Simulates failure of primary/normal source.
 - c. Voltage and Frequency Sensing:
 - 1) Undervoltage sensing for each phase of primary/normal source; adjustable dropout/pickup settings.
 - 2) Undervoltage sensing for alternate/emergency source; adjustable dropout/pickup settings.
 - 3) Underfrequency sensing for alternate/emergency source; adjustable dropout/pickup settings.
 - d. Outputs:

- 1) Contacts for engine start/shutdown (except where direct generator communication interface is provided).
 - 2) Auxiliary contacts; one set(s) for each switch position.
 - e. Adjustable Time Delays:
 - 1) Engine generator start time delay; delays engine start signal to override momentary primary/normal source failures.
 - 2) Transfer to alternate/emergency source time delay.
 - 3) Retransfer to primary/normal source time delay.
 - 4) Engine generator cooldown time delay; delays engine shutdown following retransfer to primary/normal source to permit generator to run unloaded for cooldown period.
 - f. In-Phase Monitor (Open Transition Transfer Switches): Monitors phase angle difference between sources for initiating in-phase transfer.
 - g. Engine Exerciser: Provides programmable scheduled exercising of engine generator selectable with or without transfer to load; provides memory retention during power outage.
 - h. Retransfer to Normal Switch: Bypasses time delays for retransfer to primary/normal source.
3. Status Indications:
 - a. Connected to alternate/emergency source.
 - b. Connected to primary/normal source.
 - c. Alternate/emergency source available.
 - d. Primary/normal source available.
 4. Other Features:
 - a. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
 5. Automatic Sequence of Operations:
 - a. Upon failure of primary/normal source for a programmable time period (engine generator start time delay), initiate starting of engine generator where applicable.
 - b. When alternate/emergency source is available, transfer load to alternate/emergency source after programmable time delay.
 - c. When primary/normal source has been restored, retransfer to primary/normal source after a programmable time delay. Bypass time delay if alternate/emergency source fails and primary/normal source is available.
 - d. Where applicable, initiate shutdown of engine generator after programmable engine cooldown time delay.

2.03 SOURCE QUALITY CONTROL

- A. Perform production tests on transfer switches at factory to verify operation and performance characteristics prior to shipment. Include certified test report with submittals.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of transfer switches are consistent with the indicated requirements.
- C. Verify that rough-ins for field connections are in the proper locations.
- D. Verify that mounting surfaces are ready to receive transfer switches.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances and required maintenance access.

- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Install transfer switches plumb and level.
- F. Unless otherwise indicated, mount floor-mounted transfer switches on properly sized 4 inch high concrete pad constructed in accordance with concrete Section.

3.03 FIELD QUALITY CONTROL

- A. Prepare and start system in accordance with manufacturer's instructions.
- B. Automatic Transfer Switches:
 - 1. Inspect and test in accordance with NETA ATS, except Section 4.
 - 2. Perform inspections and tests listed in NETA ATS, Section 7.22.3. The insulation-resistance tests listed as optional are not required.
- C. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.

3.04 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.05 CLOSEOUT ACTIVITIES

- A. Demonstration: Demonstrate proper operation of transfer switches to Owner, and correct deficiencies or make adjustments as directed.
- B. Training: Train Owner's personnel on operation, adjustment, and maintenance of transfer switches.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.

3.06 PROTECTION

- A. Protect installed transfer switches from subsequent construction operations.

3.07 MAINTENANCE

- A. Provide to Owner a proposal as an alternate to the base bid, a separate maintenance contract for the service and maintenance of transfer switches for two years from date of Substantial Completion; Include a complete description of preventive maintenance, systematic examination, adjustment, inspection, and testing, with a detailed schedule.
- B. Provide trouble call-back service upon notification by Owner:
 - 1. Provide on-site response within 4 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.
- C. Maintain an on-site log 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.

END OF SECTION

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SECTION 26 41 13
LIGHTNING PROTECTION FOR STRUCTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Strike (air) terminals and interconnecting conductors.
- B. Grounding and bonding for lightning protection.

1.02 REFERENCE STANDARDS

- A. NFPA 780 - Standard for the Installation of Lightning Protection Systems 2023.
- B. UL 96 - Lightning Protection Components Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination with Concrete Work: Coordinate the embedding of lightning protection components in concrete.
- B. Coordination with Roofing Work: Ensure adequate attachment of strike terminals and conductors without damage to roofing.
- C. Preinstallation Meeting: Convene a meeting at least at least two weeks prior to commencement of any work affected by lightning protection system requirements to discuss prerequisites and coordination required by other installers; require attendance by representatives of installers whose work will be affected.

1.04 SUBMITTALS

- A. Shop Drawings: Indicate location and layout of air terminals, grounding electrodes, and bonding connections to structure and other metal objects. Include terminal, electrode, and conductor sizes, and connection and termination details.
- B. Product Data: Provide dimensions and materials of each component, indication of testing agency listing, and installation instructions.
- C. Installation Certification: Submit copy of certification agency's approval.
- D. Operation and Maintenance Data: Provide recommended inspection and testing plan, including recommended intervals, to achieve periodic maintenance as recommended in NFPA 780; provide customized plan reflecting actual installation configuration with specific installed components identified.
- E. Project Record Documents: Record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors in project record documents.

1.05 QUALITY ASSURANCE

- A. Maintain one copy of each referenced system design standard on site.
- B. Designer Qualifications: Person or entity, employed by installer, who specializes in lightning protection system design with minimum three years documented experience.
- C. Installer Qualifications: Capable of providing the specified certification of the installed system.
- D. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.01 LIGHTNING PROTECTION SYSTEM

- A. Lightning Protection System: Provide complete system complying with NFPA 780, including air terminals, bonding, interconnecting conductors and grounding electrodes.
- B. Provide system certified by LPI.
 - 1. Provide system that protects:
 - a. The entire structure.
 - b. Open air areas within building footprint.
 - 2. Coordinate with other grounding and bonding systems specified.

3. Provide copper, bronze, or stainless steel components, except where aluminum is allowed by NFPA 780.
 4. Provide system certified by Underwriters Laboratories or the Lightning Protection Institute.
- C. Strike Terminals: Provide strike (air) terminals as recommended by the Lightning Protection Institute.

2.02 COMPONENTS

- A. All Components: Complying with applicable requirements of UL 96.
- B. Strike (Air) Terminals: Aluminum, solid, with adhesive bases for single-ply roof installations.
- C. Grounding Rods: Copper-clad steel.
- D. Ground Plate: Copper.
- E. Conductors: Aluminum except transition to copper within 48 inches of earth.
- F. Connectors and Splicers: Aluminum unless conductor is copper.,

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated on shop drawings.
- B. Coordinate work with installation of roofing and exterior and interior finishes.

3.02 INSTALLATION

- A. Install in accordance with referenced system standards and as required for specified certification.
- B. Connect conductors using mechanical connectors or exothermic welding process; protect adjacent construction elements and finishes from damage.

3.03 FIELD QUALITY CONTROL

- A. Perform visual inspection as specified in NFPA 780 as if this were a periodic follow-up inspection.
- B. Perform continuity testing as specified in NFPA 780 as if this were testing for periodic maintenance.
- C. Obtain the services of the specified certification agency to provide inspection and certification of the lightning protection system, including performance of any other testing required by that agency.

END OF SECTION

**SECTION 26 43 00
SURGE PROTECTIVE DEVICES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Surge protective devices for service entrance locations.
- B. Surge protective devices for distribution locations.
- C. Surge protective devices for branch panelboard locations.

1.02 ABBREVIATIONS AND ACRONYMS

- A. EMI/RFI: Electromagnetic Interference/Radio Frequency Interference.
- B. SPD: Surge Protective Device.

1.03 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- C. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL 1449 - Standard for Surge Protective Devices Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate size and location of overcurrent device compatible with the actual surge protective device and location to be installed. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to ordering equipment.

1.05 SUBMITTALS

- A. Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.
- B. Certificates: Manufacturer's documentation of listing for compliance with the following standards:
 - 1. UL 1449.
 - 2. UL 1283 (for Type 2 SPDs).
- C. Operation and Maintenance Data: Include information on status indicators and recommended maintenance procedures and intervals.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Store in a clean, dry space in accordance with manufacturer's written instructions.

1.08 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Field-installed, Externally Mounted Surge Protective Devices:
 - 1. ABB/GE: www.geindustrial.com/#sle.
 - 2. Advanced Protection Technologies, Inc (APT): www.aptsurge.com/#sle.

3. Current Technology; a brand of Thomas & Betts Power Solutions:
www.tnbpowersolutions.com/#sle.
4. Schneider Electric; Square D Brand Surgellogic Products: www.surgellogic.com/#sle.
- B. Factory-installed, Internally Mounted Surge Protective Devices:
 1. Same as manufacturer of equipment containing surge protective device, to provide a complete listed assembly including SPD.
- C. Source Limitations: Furnish surge protective devices produced by a single manufacturer and obtained from a single supplier.

2.02 SURGE PROTECTIVE DEVICES - GENERAL REQUIREMENTS

- A. Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service; listed, classified, and labeled as suitable for the purpose intended; system voltage as indicated on the drawings.
- B. Unless otherwise indicated, provide field-installed, externally-mounted or factory-installed, internally-mounted SPDs.
- C. List and label as complying with UL 1449, Type 1 when connected on line side of service disconnect overcurrent device and Type 1 or 2 when connected on load side of service disconnect overcurrent device.
- D. Protected Modes:
 1. Wye Systems: L-N, L-G, N-G, L-L.
- E. UL 1449 Voltage Protection Ratings (VPRs):
 1. 208Y/120V System Voltage: Not more than 700 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.
 2. 480Y/277V System Voltage: Not more than 1,200 V for L-N, L-G, and N-G modes and 2,000 V for L-L mode.
- F. UL 1449 Maximum Continuous Operating Voltage (MCOV): Not less than 115% of nominal system voltage.
- G. Enclosure Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 1. Indoor clean, dry locations: Type 1.
 2. Outdoor locations: Type 3R.
- H. Mounting for Field-installed, Externally Mounted SPDs: Unless otherwise indicated, as specified for the following locations:
 1. Provide surface-mounted SPD where mounted in non-public areas or adjacent to surface-mounted equipment.
- I. Equipment Containing Factory-installed, Internally Mounted SPDs: Listed and labeled as a complete assembly including SPD.

2.03 SURGE PROTECTIVE DEVICES FOR SERVICE ENTRANCE LOCATIONS

- A. Surge Protective Device:
 1. Protection Circuits: Field-replaceable modular or non-modular.
 2. Surge Current Rating: Not less than 120 kA per mode/240 kA per phase.
 3. UL 1449 Nominal Discharge Current (I-n): 20 kA.
 4. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.
 5. Diagnostics:
 - a. Protection Status Monitoring: Provide indicator lights to report the protection for each phase.
 - b. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
 - c. Surge Counter: Provide surge event counter with manual reset button, surge count retention upon power loss, and six digit LCD display that indicates quantity of surge events.

6. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch.

2.04 SURGE PROTECTIVE DEVICES FOR DISTRIBUTION LOCATIONS

- A. Surge Protective Device:
 1. Protection Circuits: Field-replaceable modular or non-modular.
 2. Surge Current Rating: Not less than 80 kA per mode/160 kA per phase.
 3. UL 1449 Nominal Discharge Current (I-n): 20 kA.
 4. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.
 5. Diagnostics:
 - a. Protection Status Monitoring: Provide indicator lights to report the protection status for each phase.
 - b. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
 6. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch.

2.05 SURGE PROTECTIVE DEVICES FOR BRANCH PANELBOARD LOCATIONS

- A. Surge Protective Device:
 1. Protection Circuits: Field-replaceable modular or non-modular.
 2. Surge Current Rating: Not less than 60 kA per mode/120 kA per phase.
 3. UL 1449 Nominal Discharge Current (I-n): 20 kA.
 4. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.
 5. Diagnostics:
 - a. Protection Status Monitoring: Provide indicator lights to report the protection status for each phase.
 - b. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
 6. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the service voltage and configuration marked on the SPD are consistent with the service voltage and configuration at the location to be installed.
- C. Verify that electrical equipment is ready to accept connection of the SPD and that installed overcurrent device is consistent with requirements of drawings and manufacturer's instructions.
- D. Verify system grounding and bonding is in accordance with Section 26 05 26, including bonding of neutral and ground for service entrance and separately derived systems where applicable. Do not energize SPD until deficiencies have been corrected.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Unless indicated otherwise, connect service entrance surge protective device on load side of service disconnect main overcurrent device.
- E. Provide conductors with minimum ampacity as indicated on the drawings, as required by NFPA 70, and not less than manufacturer's recommended minimum conductor size.

- F. Install conductors between SPD and equipment terminations as short and straight as possible, not exceeding manufacturer's recommended maximum conductor length. Breaker locations may be reasonably rearranged in order to provide leads as short and straight as possible. Twist conductors together to reduce inductance.
- G. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 05 26 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.

3.03 CLEANING

- A. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

**SECTION 26 51 00
INTERIOR LIGHTING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Interior luminaires.
- B. Emergency lighting units.
- C. Exit signs.
- D. Ballasts and drivers.

1.02 REFERENCE STANDARDS

- A. IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products 2019.
- B. IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources 2021.
- C. NECA/IESNA 500 - Standard for Installing Indoor Lighting Systems 2006.
- D. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility 2012 (Reaffirmed 2018).
- E. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NFPA 101 - Life Safety Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. UL 924 - Emergency Lighting and Power Equipment Current Edition, Including All Revisions.
- H. UL 1598 - Luminaires Current Edition, Including All Revisions.
- I. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
 - 2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
 - 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
 - 4. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.04 SUBMITTALS

- A. 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.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.06 DELIVERY, STORAGE, AND PROTECTION

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting) and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.07 FIELD CONDITIONS

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

1.08 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide three year manufacturer warranty for LED luminaires, including drivers.

PART 2 PRODUCTS

2.01 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the drawings.

2.02 LUMINAIRES

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, supports, trims, accessories, etc. as necessary for a complete operating system.
- F. Provide products suitable to withstand normal handling, installation, and service without any damage, distortion, corrosion, fading, discoloring, etc.
- G. Recessed Luminaires:
 - 1. Ceiling Compatibility: Comply with NEMA LE 4.
 - 2. Luminaires Recessed in Insulated Ceilings: Listed and labeled as IC-rated, suitable for direct contact with insulation and combustible materials.
 - 3. Luminaires Recessed in Sloped Ceilings: Provide suitable sloped ceiling adapters.
- H. LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

2.03 EMERGENCY LIGHTING UNITS

- A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
- B. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- C. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- D. Provide low-voltage disconnect to prevent battery damage from deep discharge.

- E. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.

2.04 EXIT SIGNS

- A. Description: Internally illuminated exit signs with LEDs unless otherwise indicated; complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
 - 1. Number of Faces: Single or double as indicated or as required for the installed location.
 - 2. Directional Arrows: As indicated or as required for the installed location.
- B. Self-Powered Exit Signs:
 - 1. 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.
 - 2. Battery: Sealed maintenance-free nickel cadmium unless otherwise indicated.
 - 3. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
 - 4. Provide low-voltage disconnect to prevent battery damage from deep discharge.
 - 5. 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.

2.05 BALLASTS AND DRIVERS

- A. Drivers - General Requirements:
 - 1. Provide RoHS compliant UL listed LED drivers
 - 2. Drive current shall match LED module and not overdrive LED modules.
 - 3. Operating temperature rating shall be minimum 25 degree C or maximum space conditions, which ever is greater.
- 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.
 - a. Wall Dimmers: See Section 26 27 26.
 - b. Daylighting Controls: See Section 26 09 23.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of luminaires provided under this section.
- B. Install products in accordance with manufacturer's instructions.
- C. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting).
- D. Provide required support and attachment in accordance with Section 26 05 29.

- E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F. Suspended Ceiling Mounted Luminaires:
 - 1. Do not use ceiling tiles to bear weight of luminaires.
 - 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.
 - 3. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
 - 4. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- G. Recessed Luminaires:
 - 1. Install trims tight to mounting surface with no visible light leakage.
 - 2. Non-IC Rated Luminaires: Maintain required separation from insulation and combustible materials according to listing.
 - 3. Luminaires Recessed in Fire-Rated Ceilings: Install using accessories and firestopping materials to meet regulatory requirements for fire rating.
- H. Suspended Luminaires:
 - 1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
 - 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 - 3. Install canopies tight to mounting surface.
- I. Install accessories furnished with each luminaire.
- J. Bond products and metal accessories to branch circuit equipment grounding conductor.
- K. Emergency Lighting Units:
 - 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- L. Exit Signs:
 - 1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- M. Install lamps in each luminaire.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Inspect each product for damage and defects.
- C. Operate each luminaire after installation and connection to verify proper operation.
- D. Test self-powered exit signs, emergency lighting units, and fluorescent emergency power supply units to verify proper operation upon loss of normal power supply.
- E. Correct wiring deficiencies and repair or replace damaged or defective products. Repair or replace excessively noisy ballasts as determined by Architect.

3.04 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.
- B. Aim and position adjustable emergency lighting unit lamps to achieve optimum illumination of egress path as required or as directed by Architect or authority having jurisdiction.
- C. Exit Signs with Field-Selectable Directional Arrows: Set as indicated or as required to properly designate egress path as directed by Architect or authority having jurisdiction.

3.05 CLEANING

- A. Clean surfaces according to NECA 500 (commercial lighting) and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.06 CLOSEOUT ACTIVITIES

- A. Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.
- B. Just prior to Substantial Completion, replace all lamps that have failed.

3.07 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

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**SECTION 26 56 00
EXTERIOR LIGHTING**

PART 1 GENERAL

1.01 RELATED REQUIREMENTS

- A. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- B. Section 26 05 33.16 - Boxes for Electrical Systems.

1.02 REFERENCE STANDARDS

- 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-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products 2019.
- D. IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources 2021.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction 2015.
- F. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems 2000 (Reaffirmed 2006).
- G. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 1598 - Luminaires Current Edition, Including All Revisions.
- I. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate placement of poles and associated foundations with utilities, curbs, sidewalks, trees, walls, fences, striping, etc. installed under other sections or by others. Coordinate elevation to obtain specified foundation height.
 - 2. Notify Architect of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. 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, weight, effective projected area (EPA), and installed accessories; include model number nomenclature clearly marked with all proposed features.
 - 1. LED Luminaires:
 - a. Include estimated useful life, calculated based on IES LM-80 test data.
 - 2. Poles: Include information on maximum supported effective projected area (EPA) and weight for the design wind speed.

1.05 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Receive, handle, and store products according to NECA/IESNA 501 and manufacturer's written instructions.

- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.07 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide three year manufacturer warranty for all LED luminaires, including drivers.

PART 2 PRODUCTS

2.01 LUMINAIRE TYPES

- A. Furnish products as indicated in luminaire schedule included on the drawings.

2.02 LUMINAIRES

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products that are listed and labeled as complying with UL 1598, where applicable.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Unless otherwise indicated, provide complete luminaires including lamp(s) and all sockets, ballasts, reflectors, lenses, housings and other components required to position, energize and protect the lamp and distribute the light.
- E. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, hardware, 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. 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.

2.03 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.

2.04 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.
 - 3. Material: Steel, unless otherwise indicated.
 - 4. Shape: Square straight, unless otherwise indicated.
 - 5. Finish: Match luminaire finish, unless otherwise indicated.
 - 6. Mounting: Install on concrete foundation, height as indicated on the drawings, unless otherwise indicated.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.

- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 26 05 33.16 as required for installation of luminaires provided under this section.
- B. Install products in accordance with manufacturer's instructions.
- C. Install luminaires in accordance with NECA/IESNA 501.
- D. Provide required support and attachment in accordance with Section 26 05 29.
- E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F. Pole-Mounted Luminaires:
 - 1. Maintain the following minimum clearances:
 - a. Comply with IEEE C2.
 - b. Comply with utility company requirements.
 - 2. Grounding:
 - a. Bond luminaires, metal accessories, metal poles, and foundation reinforcement to branch circuit equipment grounding conductor.
 - 3. Install separate service conductors, 10 AWG copper, from each luminaire down to handhole for connection to branch circuit conductors.
- G. Install accessories furnished with each luminaire.
- H. Bond products and metal accessories to branch circuit equipment grounding conductor.
- I. Install lamps in each luminaire.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - 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.

3.04 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Architect. Secure locking fittings in place.

3.05 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.

3.06 CLOSEOUT ACTIVITIES

- A. Demonstration: Demonstrate proper operation of luminaires to Architect, and correct deficiencies or make adjustments as directed.
- B. Just prior to Substantial Completion, replace all lamps that have failed.

3.07 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION

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SECTION 27 05 00
COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 GENERAL

1.01 SUMMARY

- A. The purpose of this section is to provide general guidelines, required standards and documentation, and other considerations related to the Division 27 in its entirety. This section will be referred to in subsequent sections for this division and others.

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01, Division 07, and Division 08 Specification Sections, apply to this Section.
- B. Drawings and provisions of the Contract including Division 26 Electrical.

1.03 SUBMITTALS AND SHOP DRAWINGS

- A. Refer to Division 1 and the General Provisions of the Contract for exact submittal procedures.
- B. Work shall not proceed without OWNER and Technology Consultant approval of all submitted items.
- C. Shop drawings shall be submitted in advance of construction so as to cause no delay in other Contractors' work. Shop drawings shall be submitted at such time to allow the Engineer reasonable time to review shop drawings to make necessary corrections.
- D. It will be assumed that the Contractor has examined the shop drawings and equipment brochures prior to submission and that materials and equipment depicted will readily fit into the construction. Contractor shall also review all completed work related to materials or equipment depicted to ensure that it has been properly installed.
- E. Submit a specification compliance review where indicated in individual sections.
 - 1. At each paragraph of the specification indicate in the left hand margin if the paragraph "NA" not applicable, "C" complies or "E" exception. Explain fully any exceptions to the paragraphs. Shop drawings and product data will not be reviewed with out submitting the specification compliance review.
- F. No materials or equipment subject to prior review by the Engineer shall be fabricated or installed by the Contractor, without such review and approval. The Engineer's review of such drawings and brochures shall not relieve the Contractor of responsibility for deviations from the requirements of the drawings and specifications, unless he has notified the Engineer in writing
- G. The Division 27 Contractor shall provide for review, without exception prior to material acquisition and installation, multiple copies of the following items, quantity as required by the General Contractor or Construction Manager, as applicable. Specific requirements shall be listed and described within each Division 27 section. Failure to submit required items shall disqualify the bidder.
 - 1. Product Data Sheets (Catalog Cuts)
 - 2. Backbone/Riser/Cabling Diagrams
 - 3. System Schematics
 - 4. Specification Sheets for Test Equipment
 - 5. Bill of Materials
 - 6. Contracting Firm Qualifications and Certifications
 - 7. Installation Team Qualifications by Individual
 - 8. Current Manufacturer Certifications
- H. The Division 27 Contractor shall provide Coordination Drawings for review, without exception prior to material acquisition and installation for approval to proceed. Coordination Drawings shall consist of floor plans and building sections, drawn to scale. Include scaled Cable Tray/Runway layout and relationships between components and adjacent structural and mechanical elements. Show the following:
 - 1. Vertical and horizontal offsets and transitions.

2. Clearances for access above and to the side of Cable Tray/Runways.
3. Vertical elevation of Cable Tray/Runways above floor or bottom of ceiling structure.
- I. Provide throughout installation:
 1. Material samples, if requested by the Architect, Technology Consultant, General Contractor, or Construction Manager.
 2. Periodic field quality control reports.
 3. Periodic cable test reports.
- J. Provide prior to completion:
 1. Actual samples of the component labeling scheme to be applied to cabling components, to be approved by the Architect, Technology Consultant, General Contractor, or Construction Manager.
 2. Draft cable administration drawings, as requested to assist OWNER in the planning process. Drawings will be requested prior to final documentation and as Xerox reproductions of hand written field copies.
- K. Provide at completion of each construction/testing phase or area, as defined by the General Contractor or Construction Manager:
 1. Cable test and certification reports; summary hard copy or full test results on compact disc or USB drive when requested by the General Contractor or Construction Manager, OWNER Networking & Telecommunications, or the Technology Consultant. Reports shall be submitted to the requesting party within thirty (30) working days of completion for each phase.
 2. One (1) full size set of final drawings of the actual installation for the Division 27 systems. Drawings shall be given as D or E size originals and on disc or USB drive in AutoCAD format.
- L. Provide after the installation is complete
 1. One (1) full size set of record drawings of the actual installation for the Division 27 systems. Drawings shall be given as D or E size originals and on disc or USB drive in AutoCAD format.
- M. Provide after the installation is complete and two (2) weeks before final acceptance, three (3) bound sets of O&M (Operating and Maintenance) Manuals formatted as defined by Division 1 and within Section 27 00 00. In addition to the specific requirements contained within each Division 27 sub-section, each copy of the O&M Manual shall include, at minimum, items listed as follows:
 1. One (1) copy of each approved submittal.
 2. Cable test and certification reports; summary hard copy and full test results on disc or USB drive.
 - a. All test data, including documentation of failed tests, the corrective procedures performed, and the results of re-tests are to be documented and submitted in both hard copy and ASCII format on CD-ROM disc.
 - b. Hand written test reports shall not be accepted.
 - c. All actions required to correct failed tests shall be documented to include the cable identifier, tests that were failed, and actions performed to correct the problem.
 3. Instruction manuals including equipment and cable schedules, operating instructions, and manufacturer's instructions.
 4. Manufacturer Warranty Certificate.
 5. Warranty contacts including but not limited to: names and telephone numbers (office and mobile).

1.04 CODE AND STANDARDS

- A. All work shall be in compliance with all applicable codes and regulations. Nothing contained within these Specifications shall be misconstrued to permit work not in conformance with the most stringent of applicable codes and standards. It is assumed that bidders have access to, and specific knowledge of, these reference materials in order to ensure conformity with them.
- B. Refer to Division 1 – Reference Standards and General Conditions of the Contract

1.05 COORDINATION WITH OTHER TRADES

- A. Coordinate layout of work with other trades. Make minor adjustments in location required for coordination. Locations of structural systems, heating work and plumbing lines shall take preference over locations of conduit lines where conflict occurs. Structural systems, heating work, and plumbing lines shall not interfere with or otherwise impede the routing of communication cabling with cable tray, raceways, or other pathways dedicated to communications. All potential issues shall be brought to the attention of the General Contractor or Construction Manager immediately, before proceeding with installation.
- B. Other than minor adjustments shall be submitted to the General Contractor or Construction Manager for approval before proceeding with the work.
- C. Coordinate locations, arrangement, mounting, and support of all communications provisions with Division 26.
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So that connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- D. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- E. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 and Division 26
- F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08.
- G. The location of TO(s) and WAO(s) shown on the Drawings is approximate, and the General Contractor or Construction Manager shall have the right to relocate any TO(s) or WAO(s) before they are installed without additional cost.

PART 2 PRODUCTS

2.01 WARRANTY

- A. Provide warranties as required by subsequent sections of this division. Documents verifying the duration, included services and maintenance, and the contractor's ability to provide the warrantied installation and maintenance, shall be provided prior to the start of installation.

PART 3 EXECUTION

3.01 FIELD CONDITIONS

- A. Examine all elements intended for Communications. Check pathways, raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, installation hazards or impediments, and other conditions affecting installation. Verify that all work required in the field is adequately described in the plans. Proceed with installation only after unsatisfactory conditions and discrepancies have been brought to the attention of the General Contractor or Construction Manager and corrected.
- B. Unless otherwise noted, the footages for cabling and materials shown on the Project Drawings are based upon available plant records, architectural drawings, or the Engineer's route and pathway assumptions. The Contractor shall be required to perform field surveys and measurements, prior to ordering materials.

3.02 COMMON INSTALLATION REQUIREMENTS

- A. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall mounting items.
- B. 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.

- C. 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.
- D. Right of Way: Give to piping systems installed at a required slope.
- E. The Contractor shall contact Owner before commencement of work and shall coordinate with Owner personnel and all other trades. Commencement of work shall be coordinated through the General Contractor or Construction Manager.

END OF SECTION

SECTION 27 05 10
PROVISIONS FOR OWNER-FURNISHED COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Outlet and junction boxes, raceways, conduit sleeves, cable tray and fire-rated assemblies for Owner-furnished communications systems.
- B. The following Systems will be selected and provided by the Owner.
 - 1. Telephone with Voice Mail
 - 2. Wireless Telephone
 - 3. HIS Network and Computer Equipment
 - 4. Network Cabling Infrastructure - Voice, Data and Video
 - 5. Public Address Paging
 - 6. Intercom
 - 7. MATV, CATV and SATV - Television Distribution

1.02 SUBMITTALS – ACTION

- A. Prepare submittals per requirements of Division 01 Sections.
- B. Product Data: For outlet and junction boxes, raceways, conduit sleeves, cable tray and fire-rated assemblies.

1.03 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 NFPA 70.

PART 2 - PRODUCTS

2.01 EQUIPMENT AND MATERIALS

- A. The Owner's Vendors shall furnish and install system equipment, power unit cabinets, and cable for the systems.
- B. Owner's Vendors shall furnish special boxes for Contractor installation.
- C. Furnish and install standard boxes, conduit stub-ups, sleeves, power, and items required in this Section.
- D. Furnish and install in smoke-rated or fire-rated walls above corridor doors and into communications equipment rooms, telephone rooms and data centers 4 inch x 4 inch fire-rated assembly, Specified Technologies, Inc. "EZ-Path Fire Rated Pathway" or as approved by Design Professional.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Furnish and install 4' x 8' x 3/4" fire retardant plywood on all walls of the communication equipment rooms from floor to 96 inches AFF.
- B. Provide a No. 6 AWG copper ground conductor installed in conduit in the communications equipment rooms, telephone room and data center. The grounding bus-bar must be installed on all walls with communications equipment.
- C. Install telephone and CATV service entrance conduits as indicated and detailed on the drawings. Type of conduit as specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems".
- D. Receive, store, and protect all equipment and cable. Store in dry location only.
- E. Furnish and install conduit and standard boxes per the Drawings.

- F. Install special boxes, furnished by the Owner's Vendors, with conduit stub-ups per the Drawings.
- G. Coordinate box installation to avoid interference with other faceplates.
- H. Each system box shall be served by a separate conduit stubbed up above accessible ceilings. Minimum size of conduit shall be 3/4-inch with bushing.
- I. Provide a 1-inch sleeve for each system into each space which contains a box which does not have the conduit stub-up turned into the adjacent corridor ceiling.
- J. Where open cable is run above dropped ceilings and penetrates a smoke or fire rated wall, provide a minimum 1-inch empty sleeve, extending at least one foot on both sides of the partition with bushings on both ends. Provide larger sized sleeves where indicated on the drawings. Seal around cable to maintain wall rating.
- K. Furnish and install 4 inch by 4 inch fire-rated assemblies in smoke or fire-rated walls above corridor doors and into communications equipment rooms, telephone room and data center.
- L. Fire caulk all conduit and sleeves.
- M. Core drill and fire caulk floor penetrations.
- N. Coordinate with Vendors for the exact quantity, size, and location of wall sleeves.
- O. Coordinate with Vendors the exact quantity and location of the 4 inch by 4 inch fire-rated assemblies.
- P. Install 200-pound test nylon pull line in all empty raceways. Pull line shall be the entire length of the raceway and extend three feet beyond on each end.
- Q. Furnish and install a J-hook system in main and adjoining corridors to meet cabling requirements. Use BICSI standards to ensure the size and weight of the cables will be properly supported.
- R. Vendors shall furnish and install J-hooks in rooms or spaces to get their cables to the nearest sleeve that accesses the closest accessible corridor ceiling.
- S. Coordinate installation of all other trades systems to not interfere with access to cable tray and J-hook system. Provide a 12-inch minimum clearance for installing cable in pathways.
- T. Furnish and install in-wall and above ceiling structural supports for television brackets, video monitor brackets, projector brackets, antenna brackets, projection screens, shelves, etc. Refer to Vendor shop drawings and submittals for support details.
- U. Install wall and ceiling brackets that are furnished by the Owner's Vendors. Refer to Vendor shop drawings and submittals for installation details.
- V. Furnish and install shelves. Refer to Vendor shop drawings and submittals for installation details.
- W. Schedule installation of the systems with Owner's Vendors.
- X. Provide blank cover plates for any unused boxes at project completion.
- Y. Owner's Vendors will test and certify their systems. Contractor shall assist the Vendors.
- Z. Coordinate review by the Owner's Vendors of the Contract Documents to verify their provisions will accommodate the installation of the proposed additions to the systems. Report discrepancies promptly to the Design Professional.

END OF SECTION

SECTION 27 05 26
GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

GENERAL

1.01 SUMMARY

- A. The purpose of this section is to provide direction on the grounding and bonding requirements for systems covered by this division. This section will be referred to in subsequent sections of this division and others.
- B. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.
 - 4. Grounding rods.
 - 5. Grounding labeling.

1.02 SUBMITTALS

- A. ACTION SUBMITTALS
 - 1. Product Data: For each type of product.
 - 2. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.
- B. INFORMATIONAL SUBMITTALS
 - 1. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 - a. Ground rods.
 - b. Ground and roof rings.
 - c. BCT, PBB, SBBs, and routing of their bonding conductors.
 - 2. Qualification Data: For installation supervisor, and field inspector.
 - 3. Qualification Data: For testing agency and testing agency's field supervisor.
 - 4. Field quality-control reports.
- C. CLOSEOUT SUBMITTALS
 - 1. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.

1.03 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Installation Supervision: Installation shall be under the direct supervision of ITS Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 2. Field Inspector: Currently registered by BICSI as a designer RCDD to perform the on-site inspection.

PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with TIA-607-C.

2.02 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Harger Lightning & Grounding.
 - 2. Panduit Corp.
 - 3. TE Connectivity Ltd.

- B. Comply with UL 486A-486B.
- C. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the PBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- D. Underground Grounding Conductors:
 - 1. Install bare copper conductor, No. 2 AWG minimum.
- E. Grounding Electrode System:
 - 1. The BCT between the PBB and the ac service equipment ground shall not be smaller than No. 1/0 AWG.
- F. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
- G. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Sizes and types of conductors in three subparagraphs below are typical examples. 28-kcmil (14.2-sq. mm) bonding cable in "Bonding Cable" Subparagraph is slightly larger than No. 6 AWG.
 - a. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
 - b. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - c. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.03 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Chatsworth Products, Inc.
 - 2. Harger Lightning & Grounding.
- B. Terminations and Connections: TIA-232
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.
- C. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- D. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
 - 1. Electroplated tinned copper, C and H shaped.
- E. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.
- F. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.

- G. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.04 JUMPERS

- A. Cable Tray Grounding Jumper:
 - 1. Not smaller than No. 6 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.
 - 2. Not smaller than No. 10 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with one hole and standard barrel for one crimp. If jumper is a flexible braid, it shall have a one- or two-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

EXECUTION

3.01 EXAMINATION

- A. Examine the ac 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 the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of BCT connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-C.
- D. Grounding and Bonding Conductors:
 - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 - 2. Install without splices.
 - 3. Support at not more than 36-inch intervals.
 - 4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
- E. Cable Basket and Trays:
 - 1. Ground cable trays according to NFPA 70 unless additional grounding is specified.
 - 2. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
 - 3. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."
 - 4. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

5. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."
- F. Connections:
 1. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
 2. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
 3. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 - a. Use crimping tool and the die specific to the connector.
 - b. Pre-twist the conductor.
 - c. Apply an antioxidant compound to all bolted and compression connections.
 4. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.
 5. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.
 6. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each SBB to the ground bar of the panelboard.
 7. Shielded Cable: Bond the shield of shielded cable to the SBB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.
 8. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.
 9. Access Floors: Bond all metal parts of access floors to the SBB.
 10. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using No. 6 AWG bonding conductors.
 - a. Install the conductors in grid pattern on 4-foot centers, allowing bonding of one pedestal from each access floor tile.
 - b. Bond the SBB of the equipment room to the reference grid at two or more locations.
 - c. Bond all conduits and piping entering the equipment room to the SBB at the perimeter of the room.
 11. Towers and Antennas:
 - a. Ground Ring: Buried at least 30 inches below grade and at least 24 inches from the base of the tower or mounting.
 - b. Bond each tower base and metallic frame of a dish to the ground ring, buried at least 18 inches below grade.
 - c. Bond the ground ring and antenna grounds to the equipment room PBB or SBB, buried at least 30 inches below grade.
 - d. Bond metallic fences within 6 feet of towers and antennas to the ground ring, buried at least 18 inches below grade.
 - e. Special Requirements for Roof-Mounted Towers:
 - 1) Bond tower base footings steel, the SBB in the equipment room, and antenna support guys to the roof ring.
 - 2) Connect roof ring to the perimeter conductors of the lightning protection system.
 - f. Waveguides and Coaxial Cable:
 - 1) Bond cable shields at the point of entry into the building to the SBB and to the cable entrance plate, using No. 2 AWG bonding conductors.
 - 2) Bond coaxial cable surge arrester to the ground or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

G. GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

1. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
2. Comply with IEEE C2 grounding requirements.
3. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches extends 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 above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.
4. 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, bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect grounding conductors to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.03 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a PBB and a SBB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
 - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the PBB and in each SBB. Maximum acceptable ac current level is 1 A.
- D. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.
- E. Grounding system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

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SECTION 27 05 28
PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

- A. The purpose of this section is to provide direction one productions and installation practices to be used for the low-voltage pathways systems, including cable trays, sleeves, penetrations, and hangers and supports.
- B. Section Includes:
 - 1. Tray:
 - a. Ladder cable tray.
 - b. Wire-mesh cable tray.
 - c. Single-rail cable tray.
 - d. Trough cable tray.
 - e. Fiberglass cable tray.
 - f. Cable tray accessories.
 - g. Warning signs.
 - 2. Hangers and Supports:
 - a. Steel slotted support systems for communication raceways.
 - b. Aluminum slotted support systems for communication raceways.
 - c. Nonmetallic slotted support systems for communication raceways.
 - d. Conduit and cable support devices.
 - e. Support for conductors in vertical conduit.
 - f. Structural steel for fabricated supports and restraints.
 - g. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
 - h. Fabricated metal equipment support assemblies.
 - 3. Sleeves and Slots:
 - a. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
 - b. Sleeve-seal systems.
 - c. Sleeve-seal fittings.
 - d. Grout.
 - e. Silicone sealants.

1.02 RELATED DOCUMENTS

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

1.03 SUBMITTAL ITEMS

- A. Action Submittals:
 - 1. Product Data:
 - a. Tray
 - 1) Include data indicating dimensions and finishes for each type of cable tray indicated.
 - b. Hangers and Supports
 - 1) Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - (a) Slotted support systems, hardware, and accessories.
 - (b) Clamps.
 - (c) Hangers.
 - (d) Sockets.
 - (e) Eye nuts.
 - (f) Fasteners.

- (g) Anchors.
 - (h) Saddles.
 - (i) Brackets.
 - 2) Include rated capacities and furnished specialties and accessories.
- 2. Shop Drawings
 - a. Tray
 - 1) Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
 - 2) Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - (a) Vertical and horizontal offsets and transitions.
 - (b) Clearances for access above and to sides of cable trays.
 - (c) Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - (d) Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
 - b. Hangers and Supports
 - 1) Trapeze hangers. Include product data for components.
 - 2) Steel slotted-channel systems.
 - 3) Aluminum slotted-channel systems.
 - 4) Nonmetallic slotted-channel systems.
 - 5) Equipment supports.
 - 6) Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- 3. Delegated-Design Submittal: For seismic restraints.
 - a. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
 - b. Design Calculations: Calculate requirements for selecting seismic restraints.
 - c. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.
 - d. Include design calculations and details of trapeze hangers.
- B. Informational Submittals:
 - 1. Coordination Drawings: Details, reflected ceiling plans, floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Tray
 - 1) Scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
 - 2) Vertical and horizontal offsets and transitions.
 - 3) Clearances for access above and to side of cable trays.
 - 4) Vertical elevation of cable trays above the floor or below bottom of ceiling structure.
 - b. Hangers and Supports
 - 1) Suspended ceiling components.
 - 2) Ductwork, piping, fittings, and supports.
 - 3) Structural members to which hangers and supports will be attached.
 - 4) Size and location of initial access modules for acoustical tile.
 - 5) Items penetrating finished ceiling, including the following:
 - (a) Luminaires.
 - (b) Air outlets and inlets.

- (c) Speakers.
 - (d) Sprinklers.
 - (e) Access panels.
 - (f) Projectors.
- c. Sleeves and Slots
- 2. Seismic Qualification Data: Certificates, for cable trays, accessories, and components, from manufacturer.
- 3. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- 4. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- 5. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 6. Field quality-control reports.
- 7. Welding Certificates

PART 2 PRODUCTS

2.01 TRAY

- A. PERFORMANCE REQUIREMENTS
 - 1. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 - a. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.
- B. GENERAL REQUIREMENTS FOR CABLE TRAYS
 - 1. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
 - a. Source Limitations: Obtain cable trays and components from single manufacturer.
 - 2. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
 - 3. Structural Performance: See articles for individual cable tray types for specific values for the following parameters.
 - a. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 - b. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 - c. Load and Safety Factors: Applicable to both side rails and rung capacities.
- C. LADDER CABLE TRAY
 - 1. Description:
 - a. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
 - b. Width: 12 inches unless otherwise indicated on Drawings.
 - c. Minimum Usable Load Depth: 4 inches.
 - d. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
 - e. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
 - f. No portion of the rungs shall protrude below the bottom plane of side rails.
 - g. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
 - h. Fitting Minimum Radius: 24 inches.
 - i. Class Designation: Comply with NEMA VE 1, Class 12A.
 - j. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - k. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
 - l. Covers: Louvered type made of same materials and with same finishes as cable tray.
 - 2. Materials and Finishes:

- a. Steel:
 - 1) Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - 2) Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
 - 3) Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2.
 - 4) Finish: Powder-coat enamel.
 - (a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - (b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - (c) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - b. Aluminum:
 - 1) Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
 - 2) Hardware: Chromium-zinc-plated steel, ASTM F 1136.
 - 3) Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
 - c. Stainless Steel:
 - 1) Materials: Low-carbon, passivated stainless steel, Type 304L or Type 316L, ASTM F593 and ASTM F594.
 - 2) Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
- D. WIRE-MESH CABLE TRAY
- 1.
 - 2. Description:
 - a. Configuration: Steel wire mesh, complying with NEMA VE 1.
 - b. Width: 4 inches unless otherwise indicated on Drawings.
 - c. Minimum Usable Load Depth: 2 inches.
 - d. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
 - e. Class Designation: Comply with NEMA VE 1, Class 12AA.
 - f. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - g. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
 - 3. Materials and Finishes:
 - a. Steel:
 - 1) Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - 2) Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
 - 3) Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2.
 - (a) Hardware: Galvanized, ASTM B633.
 - 4) Finish: Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, G90.
 - (a) Hardware: Galvanized, ASTM B633.
 - 5) Finish: Electrogalvanized after fabrication, complying with ASTM B633.
 - (a) Hardware: Galvanized, ASTM B633.
 - 6) Finish: Epoxy-resin or Powder-coat enamel paint.
 - (a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - (b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - (c) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - (d) Hardware: Chromium-zinc plated, ASTM F1136.

E. SINGLE-RAIL CABLE TRAY

- 1.
2. Description:
 - a. Configuration: An extruded-aluminum assembly, consisting of a single longitudinal center rail with transverse rungs arranged symmetrically about the center rail complying with NEMA VE 1.
 - b. Construction: Aluminum rungs mechanically connected to aluminum center rail in at least two places, with ends finished to protect installers and cables.
 - c. Width: 6 inches unless otherwise indicated on Drawings.
 - d. Minimum Usable Load Depth: 3 inch.
 - e. Rung Spacing: 9 inches o.c.
 - f. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
 - g. Support Point: Splice fittings shall be hanger support point.
 - h. Support Spacing: Support each section at midpoint. Support wall-mounted sections a maximum of one-sixth of the section length from each end.
 - i. Class Designation: Comply with NEMA VE 1, Class 12AA.
 - j. Unbalanced Loads: Maintain cable tray rungs within six degrees of horizontal under all loading conditions.
 - k. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - l. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
 - m. Splices and Connectors: Protect cables from edges of center rail and do not intrude into cable fill area.
 - n. Covers: Solid type made of same materials and with same finishes as cable tray.
3. Materials: Aluminum alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
4. Hardware: Chromium-zinc-plated steel, ASTM F 1136.
5. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

F. TROUGH CABLE TRAY

1. Description:
 - a. Configuration:
 - 1) A flat bearing surface with a solid bottom contained within two longitudinal side rails, with both edges welded to the side rails complying with NEMA VE 1.
 - 2) Single, formed sheet with a solid bottom, complying with NEMA VE 1.
 - b. Covers: Solid type made of same materials and with same finishes as cable tray.
 - c. Width: 12 inch unless otherwise indicated on Drawings.
 - d. Minimum Usable Load Depth: 3 inch.
 - e. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
 - f. Fitting Minimum Radius: 12 inch.
 - g. Class Designation: Comply with NEMA VE 1, Class 12AA.
 - h. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - i. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
2. Materials and Finishes:
 - a. Steel:
 - 1) Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
 - 2) Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - 3) Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.

- 4) Finish: Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2.
 - (a) Hardware: Galvanized, ASTM B 633.
 - 5) Finish: Hot-dip mill galvanized before fabrication complying with ASTM A653/A653M, G90.
 - (a) Hardware: Galvanized, ASTM B 633.
 - 6) Finish: Electrogalvanized after fabrication, complying with ASTM B633.
 - (a) Hardware: Galvanized, ASTM B633.
 - 7) Finish: Epoxy-resin paint.
 - (a) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - (b) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - (c) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - (d) Hardware: Chromium-zinc plated, ASTM F 1136.
 - 8) Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.
 - 9) Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.
 - b. Aluminum:
 - 1) Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
 - 2) Hardware: Chromium-zinc plated, ASTM F 1136.
 - 3) Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
 - c. Stainless Steel:
 - 1) Materials: Low-carbon, passivated stainless steel, Type 304L or Type 316L, ASTM F593 and ASTM F594.
 - 2) Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.
- G. FIBERGLASS CABLE TRAY
- 1.
 2. Description:
 - a. Configuration: Two longitudinal members with rounded edges and smooth surfaces, supporting a bearing surface, complying with NEMA FG 1.
 - b. Materials: Straight section structural elements; side rails, rungs, and splice plates shall be pultruded from glass-fiber-reinforced polyester resin, complying with NEMA FG 1 and UL 568.
 - c. Width: 6 inch unless otherwise indicated on Drawings.
 - d. Minimum Usable Load Depth: 3 inch according to NEMA FG 1.
 - e. Straight Section Lengths: 10 feet.
 - f. Class Designation: Comply with NEMA VE 1, Class 12AA.
 - g. Temperature Rating: Reduce the load rating of trays exposed to temperatures above 75 deg F according to Table 4-3, "Working Loads," in NEMA FG 1.
 - h. Fitting Minimum Radius: 12 inch.
 - i. Splicing Assemblies: Minimum four nuts and bolts per plate. Splice plates shall be furnished with straight sections and fittings.
 - j. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
 - k. Fasteners: Fiberglass-encapsulated, ASTM F593 and ASTM F594 stainless steel, Type 316. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
 - l. Covers: Solid type made of same materials and with same finishes as cable tray.
- H. CABLE TRAY ACCESSORIES

1. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
2. Barrier Strips: Same materials and finishes as for cable tray.
3. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.02 HANGERS AND SUPPORTS

A. PERFORMANCE REQUIREMENTS

1. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame Rating: Class 1.
 - b. Self-extinguishing according to ASTM D635.

B. HANGERS AND SUPPORTS:

1. Approved Manufacturers:
 - a. Cooper B-Line
 - b. Erico/Caddy
 - c. Panduit Corporation

C. SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

1. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
 - a. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - b. Material for Channel, Fittings, and Accessories: Plain steel.
 - c. Channel Width: Selected for applicable load criteria.
 - d. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - h. Channel Dimensions: Selected for applicable load criteria.
2. Aluminum Slotted Support Systems: Extruded aluminum channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
 - a. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - b. Channel Material: 6063-T6 aluminum alloy.
 - c. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 - d. Channel Width: Selected for applicable load criteria.
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - h. Channel Dimensions: Selected for applicable load criteria.
3. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c., in at least one surface.
 - a. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - b. Channel Width: Selected for applicable load criteria.
 - c. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
 - d. Fitting and Accessory Materials: Same as those for channels and angles, except metal items may be stainless steel.
 - e. Rated Strength: Selected to suit applicable load criteria.

- f. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- 4. Conduit and Cable Support Devices: Steel and malleable-iron clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- 5. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications 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 made of malleable iron.
- 6. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
- 7. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - a. Verify suitability of fasteners in "Powder-Actuated Fasteners" Subparagraph below for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick.
 - b. 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.
 - c. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - d. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - e. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - f. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A325.
 - g. Toggle Bolts: All-steel springhead type.
 - h. Hanger Rods: Threaded steel.
- D. FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES
 - 1. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

2.03 SLOTS AND SLEEVES

A. SLEEVES

- 1. Wall Sleeves:
 - a. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - b. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- 2. 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.
- 3. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.
- 4. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- 5. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- 6. Sleeves for Rectangular Openings:
 - a. Material: Galvanized-steel sheet.
 - b. Minimum Metal Thickness:
 - 1) 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).
 - 2) 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).

B. SLEEVE-SEAL SYSTEMS

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
 - a. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Carbon steel.
 - c. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

C. SLEEVE-SEAL FITTINGS

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

D. Conduit Chase Pipes

1. Conduit Chase Pipes shall be provided within TR spaces in any case where ceiling tile has been provided and must be breached.
2. Electrical Metallic Tubing (EMT) and Fittings
 - a. 4" trade size
 - 1) Manufactured to ANSI C80.3 (EMT Zinc Coated)
 - 2) UL 797 (EMT – Steel)

E. GROUT

1. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

F. SILICONE SEALANTS

1. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

2.04 WARNING SIGNS

- A. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

PART 3 EXECUTION

3.01 CABLE TRAY

A. CABLE TRAY INSTALLATION

1. Install cable trays according to NEMA VE 2.
2. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
3. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
4. Remove burrs and sharp edges from cable trays.
5. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.
6. Fasten cable tray supports to building structure.
7. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

8. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
9. Support bus assembly to prevent twisting from eccentric loading.
10. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
11. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.
12. Support wire-basket cable trays with center support hangers, trapeze hangers, or wall brackets.
13. Support center support hangers or trapeze hangers for wire-basket trays with rods sized for the load.
14. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
15. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
16. Make changes in direction and elevation using manufacturer's recommended fittings.
17. Make cable tray connections using manufacturer's recommended fittings.
18. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
19. Install cable trays with enough workspace to permit access for installing cables.
20. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
21. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.
22. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
23. Install warning signs in visible locations on or near cable trays after cable tray installation.

B. CONNECTIONS

1. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
2. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

C. FIELD QUALITY CONTROL

1. Perform the following tests and inspections:
 - a. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
 - b. Visually inspect cable tray after installation. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - c. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
 - d. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
 - e. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - f. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 - g. Check for improperly sized or installed bonding jumpers.
 - h. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

- i. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.
2. Prepare test and inspection reports.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
4. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

3.02 HANGERS AND SUPPORTS

A. APPLICATION

1. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 - a. NECA 1.
 - b. NECA/BICSI 568.
 - c. TIA-569-D.
 - d. NECA 101.
 - e. NECA 102.
 - f. NECA 105.
 - g. NECA 111.
2. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
3. 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.
4. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

B. SUPPORT INSTALLATION

1. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may be supported by openings through structure members, according to NFPA 70.
2. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
3. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - a. To Wood: Fasten with lag screws or through bolts.
 - b. To New Concrete: Bolt to concrete inserts.
 - c. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - d. To Existing Concrete: Use expansion anchor fasteners.
 - e. Instead of expansion anchors, powder-actuated-driven threaded studs, provided with lock washers and nuts, may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69 Spring-tension clamps.
 - g. To Light Steel: Sheet metal screws.
 - h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

4. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.
- C. INSTALLATION OF FABRICATED METAL SUPPORTS
 1. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor communications materials and equipment.
 2. Field Welding: Comply with AWS D1.1/D1.1M.
- D. PAINTING
 1. 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.
 - a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
 2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.03 SLOTS AND SLEEVES

- A. SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS
 1. Comply with NECA 1.
 2. Comply with NEMA VE 2 for cable tray and cable penetrations.
 3. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - a. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - 1) 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.
 - b. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - c. Size pipe sleeves to provide [1/4-inch (6.4-mm)] annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 - d. 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. Deburr after cutting.
 - e. Install sleeves for floor penetrations. Extend sleeves installed in floors [2 inches (50 mm)] above finished floor level. Install sleeves during erection of floors.
 4. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - a. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - b. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
 5. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
 6. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or 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.
 7. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.
- B. SLEEVE-SEAL-SYSTEM INSTALLATION
 1. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
 2. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

C. SLEEVE-SEAL-FITTING INSTALLATION

1. Install sleeve-seal fittings in new walls and slabs as they are constructed.
2. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
3. Secure nailing flanges to concrete forms.
4. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

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**SECTION 27 11 00
COMMUNICATIONS SPACES**

PART 1 GENERAL

1.01 SUMMARY

- A. The purpose of this section is to provide guidance on the products and installation practices to be used while installing the communications spaces, including racks, cabinets, ladder tray, and other metals and accessories.
- B. Section Includes:
 - 1. 19-inch equipment racks.
 - 2. 19-inch equipment cabinets.
 - 3. Open Rack equipment racks.
 - 4. Backboards.
 - 5. Boxes, Enclosures, and Cabinets.

1.02 SUBMITTALS

- A. ACTION SUBMITTALS
 - 1. Product Data: For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 - b. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.
 - 2. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 - c. Grounding: Indicate location of TGB and its mounting detail showing standoff insulators and wall-mounting brackets.
- B. INFORMATIONAL SUBMITTALS
 - 1. Qualification Data: For [Installer,]qualified layout technician, installation supervisor, and field inspector.
 - 2. Seismic Qualification Data: Certificates, from manufacturer.
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
 - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. QUALITY ASSURANCE
 - 1. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.
 - a. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of RCDD or Technician.
 - b. Installation Supervision: Installation shall be under direct supervision of Technician or Installer 2, Copper or Fiber, who shall be present at all times when Work of this Section is performed at Project site.
 - c. Field Inspector: Currently registered by BICSI as RCDD or Technician to perform on-site inspection.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI-7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- B. UL listed.
- C. RoHS compliant.
- D. Compliant with requirements of the Payment Card Industry Data Security Standard.

2.02 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96-inches.
- B. Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."
- C. Plywood shall be AC Grade or better, void-free.
- D. All Plywood surfaces shall be painted with 2 coats of fire retardant paint.
- E. Backboard Paint: White

2.03 19-INCH EQUIPMENT RACKS

- A. Description: Two and Four-post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECA-310, 19-inch (482.6-mm) equipment mounting with an opening of 17.72-inches (450-mm) between rails.
- B. Approved Manufacturers:
 - 1. Hubbell Premise
- C. General Requirements:
 - 1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Material: Extruded aluminum.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
 - 4. Color: Black.
- D. Floor-Mounted Racks:
 - 1. Overall Height: 72 inch.
 - 2. Overall Depth: 23 inches (584.2 mm).
 - 3. Upright Depth: 3 inches (76.2 mm).
 - 4. Two-Post Load Rating: 200 lb (91 kg).
 - 5. Four-Post Load Rating: 1000 lb (454 kg).
 - 6. Number of Rack Units per Rack: 45.
 - a. Numbering: Every rack units, on interior of rack.
 - 7. Threads: 10-32.
 - 8. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
 - 9. Base shall have a minimum of four mounting holes for permanent attachment to floor.
 - 10. Top shall have provisions for attaching to cable tray or ceiling.
 - 11. Self-leveling.
- E. Wall-Mounted Racks:
 - 1. Height: 24-inches.
 - 2. Depth: 23 inches (584.2 mm).
 - 3. Load Rating: 200 lb (91 kg).
 - 4. Number of Rack Units per Rack: As indicated on Drawings.
 - 5. Threads: 10-32.
 - 6. Wall Attachment: Four mounting holes.
 - 7. Equipment Access: Integral swing.

- F. Cable Management:
 - 1. Metal, with integral wire retaining fingers.
 - 2. Baked-polyester powder coat finish.
 - 3. Vertical cable management panels shall have front and rear channels, with covers.
 - 4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.04 19-INCH EQUIPMENT CABINETS

- A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECA-310, 19-inch (482.6-mm) equipment mounting with an opening of 17.72 inches (450 mm) between rails.
- B. Approved Manufacturers:
 - 1. Hubbell Premise
- C. General Cabinet Requirements:
 - 1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Material: Extruded steel or Extruded aluminum.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
 - 4. Color: Black.
- D. Modular Freestanding Cabinets:
 - 1. Overall Height: 72 inch.
 - 2. Overall Depth: 23 inches (584.2 mm).
 - 3. Load Rating: 3000 lb.
 - 4. Number of Rack Units: 45.
 - a. Numbering: Every rack units, on interior of rack.
 - 5. Threads: 10-32.
 - 6. Removable and lockable side and top panels.
 - 7. Hinged and lockable front and rear doors.
 - 8. Adjustable feet for leveling.
 - 9. Screened ventilation openings in roof and rear door.
 - 10. Cable access provisions in roof and base.
 - 11. TGB.
 - 12. Rack-mounted, 550-cfm (260-L/s) fan with filter.
 - 13. Power strip.
 - 14. All cabinets keyed alike.
- E. Modular Wall Cabinets:
 - 1. Height: 24-inches
 - 2. Depth: 23 inches (584.2 mm).
 - 3. Load Rating: 200 lb (91 kg).
 - 4. Number of Rack Units :As indicated on Drawings.
 - 5. Threads: 10-32.
 - 6. Lockable front and rear doors.
 - 7. Louvered side panels.
 - 8. Cable access provisions top and bottom.
 - 9. Grounding lug.
 - 10. Rack-mounted, 250-cfm (118-L/s) fan.
 - 11. Power strip.
 - 12. All cabinets keyed alike.
- F. Cable Management:
 - 1. Metal, with integral wire retaining fingers.
 - 2. Baked-polyester powder coat finish.
 - 3. Vertical cable management panels shall have front and rear channels, with covers.

4. Provide horizontal crossover cable manager at top of each relay rack, with a minimum height of two rack units each.

2.05 OPEN RACK EQUIPMENT RACKS

- A. Description: Four-post racks with integral bus bars, equipment support, and dimensions meeting Open Rack Standard v1.2.
- B. Approved Manufacturers:
 1. Hubbell Premise
- C. General Requirements:
 1. Frames: Four vertical columns, with perforated top and bottom.
 2. Support Shelves: Designed to support equipment 1 rack unit (48 mm) in height.
 3. Material:
 - a. Frames and Shelves: Extruded steel or Extruded aluminum.
 - b. Bus Bars: Nickel plated copper, with silver over-plating.
 4. Finish:
 - a. Frames: Manufacturer's standard, baked-polyester powder coat.
 - b. Shelves: Hot-dip galvanized according to ASTM A 653/A 653M.
 5. Color: Black.
 6. Height: 2100 mm.
 7. Width: 600 mm.
 8. Depth: 1607 mm.
 9. Base shall have a minimum of four mounting holes for permanent attachment to floor.
 10. Top shall have provisions for attaching to cable tray or ceiling.
 11. Self-leveling.

PART 3 EXECUTION

3.01 ENTRANCE FACILITIES

- A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

3.02 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout of communications equipment spaces.
- C. Comply with BICSI ITSIMM for installation of communications equipment spaces.
- D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- E. Coordinate layout and installation of communications equipment in racks and room. Coordinate service entrance configuration with service provider.
 1. Meet jointly with system providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
 2. Record agreements reached in meetings and distribute them to other participants.
 3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment spaces to accommodate and optimize configuration and space requirements of telecommunications equipment.
 4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.
- F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
- G. Plywood:
 1. All walls must be covered with $\frac{3}{4}$ " Grade A-C plywood, sanded smooth and painted with fire-resistant paint (not fire retardant plywood unless required by local fire codes).
 2. The plywood should be mounted vertically starting at 6-inches AFF.

3. Securely fasten plywood to wall framing members. Use flush hardware and supports to mount plywood. Ensure that the strength and placement of the hardware are sufficient to handle the total anticipated load (static and dynamic) and mounting of equipment.
 4. Install from 6 inches (150 mm) to 8 feet, 6 inches (2588 mm) above finished floor. If plywood is fire rated, ensure that fire-rating stamp is visible after installation.
 5. Paint all sides of backboard with two coats of paint.
 6. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.
- H. Conduit Chase Pipes:
1. Refer to the "Pathways for Communications" section.

END OF SECTION

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SECTION 27 52 23
NURSE CALL/CODE BLUE SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Nurse console station.
- B. Single patient station.
- C. Duty stations.
- D. Bath pull cord station.
- E. Push button emergency station with code blue and staff emergency buttons.
- F. Accessories
 - 1. Nurse call cord set.
 - 2. Dummy plugs.
 - 3. Indicator LEDs.
 - 4. Station faceplates.
 - 5. Corridor dome lights and zone dome lights.
 - 6. Cable.
 - 7. Grounding components.

1.02 RELATED REQUIREMENTS

- A. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

1.03 APPLICATION

- A. Installation of a complete nurse call system with restroom pull stations, dome lights, zone lights, staff assist stations, code blue stations and patient stations. Zone lights will be located at hallway intersections and shall illuminate to indicate path to activated device. Dome lights shall be visible from hallway on either side outside of room where device activation occurred.

1.04 REFERENCE STANDARDS

- A. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.05 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: For each type of product indicated.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment cabinets and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Cabling Diagrams: Single-line block diagrams showing cabling interconnection of all components for this specific equipment. Include cable type for each interconnection.
 - 3. Station Installation Details: For built-in equipment, dimensioned and to scale.
- D. Qualification Data: For qualified Installer.
- E. Field quality-control reports.
- F. Warranty: Sample of special warranty.
- G. Operation and Maintenance Data: For nurse call equipment to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

- C. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70 and NFPA 99, by a qualified testing agency, and marked for intended location and application.

1.07 WARRANTY

- A. The equipment warranty for core system components including control, patient stations, and substations shall extend to a total of at least five years.
- B. Warranties on non-manufacturer-supplied equipment such as pillow speakers, call cords, and UPS(s) are based on that individual manufacturer's warranty.

1.08 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
- C. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Basis of Design: West-Com
- B. Substitutions: Only allowed with approval of Owner

2.02 TONE / VISUAL NURSE CALL SYSTEM

- A. NURSE CALL SYSTEM GENERAL REQUIREMENTS
 - 1. Able to program 256 patient locations for each nurse console in the network with 64 priority levels and addressable visual and audible annunciation of devices such as smoke detectors and pull cords.
 - 2. System shall supply integrated and centralized "Code Blue" and "Staff Emergency" alarms.
 - 3. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by 20 percent above those indicated without adding internal or external components or main trunk cable conductors.
 - 4. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.
 - 5. Equipment: Microprocessor, electronic, modular.
 - 6. Nurse Console Station: Programmable via a PC.
 - 7. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.
- B. Operational Requirements:
 - 1. Patient Station Routine Call: Lights an LED on the station, lights an LED on the zone dome light and corridor dome light associated with the patient's room; audible and visual indication on the LCD display at the central annunciators. At the same time, it sounds a programmed tone and illuminates an LED at intervals, at the respective duty and staff stations. The central annunciator shall indicate the calling station by room number and call/alarm type.
 - 2. Staff Emergency Call: Flashes an LED on the station, flashes an LED on the zone dome light and corridor dome light associated with the patient's room; audible and visual indication on the LCD display at the central annunciators. At the same time, it sounds a programmed tone and illuminates an LED at intervals, at the respective duty and staff

- stations. The central annunciator shall indicate the calling station by room number and call/alarm type.
3. Code Blue Call: Flashes an LED on the station, scrolls all 4 LEDs on the zone dome light and corridor dome light associated with the patient's room; audible and visual indication on the LCD display at the central annunciators. At the same time, it sounds a programmed tone and illuminates an LED at intervals, at the respective duty and staff stations. The central annunciator shall indicate the calling station by room number and call/alarm type.
 4. Cord Removal: Initiates a separate and distinct alarm when the cord set is removed from the jack in the patient station faceplate. Displays location and "Cord Out" message on nurse console station. Inserting a cord set plug resets the alarm. Stations must provide an alarm override without requiring dummy plugs.
 5. Pull Cord Station Assist Call: Lights an LED on the station, lights an LED on the zone dome light and corridor dome light associated with the patient's room; audible and visual indication on the LCD display at the central annunciators. At the same time, it sounds a programmed tone and illuminates an LED at intervals, at the respective duty and staff stations. The central annunciator shall indicate the calling station by room number and call/alarm type.
 6. Pull Cord Station Emergency Call: Flashes an LED on the station, flashes an LED on the zone dome light and corridor dome light associated with the patient's room; audible and visual indication on the LCD display at the central annunciators. At the same time, it sounds a programmed tone and illuminates an LED at intervals, at the respective duty and staff stations. The central annunciator shall indicate the calling station by room number and call/alarm type.
 7. Duty Station Operation: Lights an LED and annunciates using the same tones used on nurse console station. Non-emergency level active alarms may be muted using mute button. Highest priority alarms override other lower priority alarms.
 8. System Reset: Operating reset button at the originating station cancels signals associated with the alarm. Extinguishes the alarm LED on the originating device and clears the alarm on nurse console stations, corresponding dome lights, staff and duty stations.
 9. Nurse call devices are supervised. If a device is no longer communicating to the central controller, a system fault alarm is created.
- C. Central Equipment Cabinet (Located in I.T. Room #107):
1. Lockable metal.
 2. Houses power supplies, controls, terminal strips, and other components.

2.03 SYSTEM COMPONENTS

- A. Nurse Control Station
1. 4.3in color capacitive touchscreen display.
 2. Ability to act as a call controller to report respective devices; central cabinet equipment contains system power only.
 3. Digital display designate identification and priority of calling stations and called stations.
 4. Alarm tones and display color denotes priority of calls awaiting response.
 5. Station Selection Controls: Touchpad select stations for two-way voice communications.
 6. Signal Tones: Programmable to announce incoming calls and alarms.
 7. Pulse rate and frequency of tone identify the highest priority call awaiting response at one time.
 8. Volume Control: adjustable tone volume level.
 9. Basis of design: West-Com "NV-DMP".
- B. Single Patient Station
1. Routine, Cancel, and Code Blue buttons as well as a standard ¼ in. phono receptacle for call cord mounted in a single gang back-box.
 2. Continuous network supervision.
 3. Basis of design: West-Com "NV-VPS2/C".
- C. Duty Stations:

1. Multicolor mini-dome LED shall duplicate the corridor light activity of the assigned nursing area. Calls from devices shall have LED colors and tones consistent with call types and priority levels.
 2. Configurable audio tones that match tones, excluding custom tones, at nurse station for all call types.
 3. Adjustable volume level for each call tone.
 4. Ability to temporarily silence using optional mute button without cancelling the call.
 5. Continuous network supervision.
 6. Basis of design: West-Com "NV-eDUTY".
- D. Bath Pull Cord Station:
1. Labeled for operation, "Pull for Emergency" and "Push for Assistance"
 2. Capable of being activated with pull cord.
 3. Pull cord with bell-shaped endpiece.
 4. Activation of the station shall illuminate a reassurance LED light on the face of the unit in addition to notifying the nurse console station.
 5. Cancel button.
 6. Push for Assistance button shall be provided for nonemergency assistance request in addition to the emergency pull cord.
 7. Water resistant and able to withstand routine cleaning and chemical disinfectants.
 8. Continuous network supervision.
 9. Basis of design: West-Com "NV-WPC2/AP".
- E. Push Button Emergency Station with Code Blue and Staff Emergency Buttons:
1. Blue button labeled "CODE BLUE" and a red button labeled "STAFF EMER".
 2. Activation of the station shall illuminate a reassurance LED light on the face of the unit in addition to notifying the nurse console station.
 3. Cancel by pressing button again. Labeled "Push Again to Cancel"
 4. Mounts on a single-gang electrical box wired to the input controller.
 5. Dry contact closure activated when button is pressed and deactivated when cancelled.
 6. Two configurable optically isolated inputs.
 7. Continuous network supervision.
 8. Basis of design: West-Com "NV-PBE2/SE/CB".
- F. Nurse Call Cord Set:
1. 1/4" Plug and 96-inch white cord; cord set shall be resistant to medical gas environment equipped with momentary-action, call button switch.
 2. Ethylene oxide, sterilizable.
 3. Washable cord.
 4. Palladium switch contacts in high-impact white housing with cord-set strain relief.
 5. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
 6. Basis of design: West-Com "CC96-030".
- G. Dummy Plugs:
1. Support for a cord-out call override feature to eliminate the need for dummy plugs.
- H. Indicator LEDs: Programmable, rated life of 20 years unless otherwise indicated.
- I. Station Faceplates:
1. Hospital grade Polylac PA-765 NAT.
 2. Antimicrobial surfaces.
 3. Color: White or light gray.
 4. Permanently marked labeling identifies indicator lamps and controls.
- J. Corridor Dome Lights and Zone Dome Lights:
1. Signal lights with up to five lamps.
 2. Lamps: LED. Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.

3. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or haze when exposed to hospital cleaning agents.
 4. Light Colors: Programmable color and brightness with at least 16 unique colors.
 5. Light Patterns: Solid, fast/slow flashing, scrolling, and alternating indicators.
 6. Configurable buzzer for any alarm type.
 7. Wall or ceiling mountable.
 8. Optical contact closure input configurable to any type of alarm.
 9. Programable contact closure output relay.
 10. Continuous network supervision.
 11. Basis of design: West-Com "NV- DOME2/V".
- K. Cable:
1. Conductors: Jacketed single and multiple, twisted-pair copper cables.
 2. Sizes and Types: As recommended by equipment manufacturer.
 3. Cable for Use in Plenums: Listed and labeled for plenum installation.
- L. Grounding Components: Follow requirements in Section 27 05 26 "Grounding and Bonding for Electrical Systems."

2.04 CONDUCTORS AND CABLES

- A. Audio Cables:
1. Conductors: Jacketed, twisted-pair and twisted-multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
 2. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
 3. Shielding: For speaker/microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
 4. Minimum Shielding Coverage on Conductors: 60 percent.
 5. Plenum Cable: Listed and labeled for plenum installation.
- B. Data Cable and Hardware: Category 5e or Category 6 balanced twisted-pair cabling and hardware. Follow requirements in Section 27 13 50 "Voice and Data Communication Cabling."
- C. Power Conductors and Cables: Copper, solid, No. 18 AWG. Follow requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
- D. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Follow requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Wiring Method:
1. Install cables in raceways except within consoles, cabinets, desks, counters, and in accessible ceiling spaces where unenclosed wiring method may be used.
 - a. Install plenum cable in environmental air spaces, including plenum ceilings.
 - b. Conceal raceway and cables except in unfinished spaces.
 2. Cable Trays: Follow requirements in Section 27 05 36 "Cable Trays for Communications Systems."
 3. Conduit and Boxes: Follow requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems." Flexible metal conduit shall not be used.
 - a. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
- C. Install cables without damaging conductors, shield, or jacket.
- D. Do not bend cables, while managing or installing, to radii smaller than as recommended by manufacturer.
- E. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
1. Pull cables simultaneously if more than one is being installed in same raceway.

2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
 3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, which will not damage media or raceway.
- F. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, or fittings.
- G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Supply and use lacing bars and distribution spools.
- H. Separation of Wires: Separate speaker/microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, supply 12-inch minimum separation between conductors to speaker/microphones and adjacent parallel power and telephone wiring. Supply separation as recommended by equipment manufacturer for other conductors.
- I. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.
- J. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Supply matching networks if needed.
- K. Identification of Conductors and Cables: Follow requirements in Section 26 05 53 "Identification for Electrical Systems" for cable and wire identification.
- L. Equipment Identification:
1. Follow requirements in Section 26 05 53 "Identification for Electrical Systems" for equipment labels and signs and labeling installation requirements.

3.02 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.
- C. Grounding Provisions: Follow requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.03 FIELD QUALITY CONTROL

- A. See Section 01 40 00 - Quality Requirements, for additional requirements.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections:
1. Schedule tests a minimum of seven days in advance.
 2. Report: Submit a written record of test results.
- D. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify, by the system test, that the total system meets these Specifications and complies with applicable standards. Report results in writing.
- E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- F. Prepare test and inspection reports.

3.04 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, supply on-site assistance in adjusting sound levels and controls to suit actual occupied

conditions. Supply up to three visits to Project during other-than-normal operating hours for this purpose.

3.05 CLOSEOUT ACTIVITIES

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel and caregiver staff to adjust, use, and maintain nurse call equipment.

3.06 MAINTENANCE

- A. See Section 01 70 00 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide service and maintenance of nurse call system for one year from Date of Substantial Completion.

END OF SECTION

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SECTION 28 05 00
ELECTRONIC SECURITY GENERAL REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

- A. Furnish all material, equipment, tools, labor, and services as necessary & required to construct the fully coordinated, complete, and properly functioning Mechanical Systems as outlined in the Contract Documents.
- B. Section Includes:
 - 1. Related Documents
 - 2. Submittal Requirements
 - 3. Product Submittals
 - 4. Products
 - 5. Tamper Switches and Alarm Reporting
 - 6. Examination
 - 7. System Integration
 - 8. Wiring Installation
 - 9. Grounding
 - 10. Identification
 - 11. Field Quality Control
 - 12. Adjusting

1.02 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. Comply with following sections when included
 - 1. 017823 "Operation and Maintenance Data"
 - 2. 260500 "General Requirements for Electrical Systems"
 - 3. 260519 "Low-Voltage Electrical Power Conductors and Cables"
 - 4. 260529 "Hangers and Supports for Electrical Systems"
 - 5. 260533 "Raceways and Boxes for Electrical Systems"
 - 6. 270553 "Identification for Communications Systems"
 - 7. 270526 "Grounding and Bonding for Communications Systems"

1.03 SUBMITTAL REQUIREMENTS

- A. Provide a single, complete Submittal per Specification Section.
- B. Do not combine multiple Sections in a Submittal.
- C. Clearly select each specific product to be reviewed. Unmarked pages from catalogs will not be reviewed.
- D. Highlight and clearly call to the Engineer's attention:
 - 1. Any portion of the submittal/shop drawing that does not comply or varies from the Technology Document's requirements.
 - 2. Changes required for any associated building systems.
 - 3. Products specified but not submitted.
- E. If the Engineer has not noted an error in the Contractor's submittal, it does not relieve the Contractor from providing the correct material or equipment to fully comply with the Engineer's documents.
- F. Submit a specification compliance review where indicated in individual sections.
 - 1. At each paragraph of the specification indicate in the left hand margin if the paragraph "NA" not applicable, "C" complies or "E" exception. Explain fully any exceptions to the paragraphs. Shop drawings and product data will not be reviewed with out submitting the specification compliance review.

- G. The Design Consultant's checking and subsequent acceptance of such submittals shall not relieve the Contractor from responsibility for deviations from Drawings or Specifications unless he has, in writing, called the Design Consultant's and Architect's attention to such deviations at the time of submission, and secured written acceptance; nor shall it relieve the Contractor from responsibility for errors in dimensions, details, sizes of members, or quantities; or for omissions of components or fittings; or for not coordinating items with actual building conditions and adjacent work.

1.04 PRODUCT SUBMITTALS

- A. Product Data: Specific Components for Electronic Safety and Security, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Design Data: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.

1.05 GENERAL SCOPE OF ELECTRONIC SAFETY AND SECURITY WORK

- A. The scope of Work is defined by these Specifications and Drawings. If the Specifications and/or the Drawings are in conflict, notify the Design Professional, before proceeding with that portion of the Work, for an interpretation of precedence. The more expensive option shall be reflected in pricing when a conflict cannot be resolved prior to bidding.
- B. The term, "Design Professional" where used in Division 28 Sections of these Specifications, shall refer to the Design Professional of Record for the Division 28 Drawings and Specifications, unless otherwise noted. Any references to a design professional of record for another Division will be explicitly made as such.
- C. The term, "Prime Design Professional" where used in Division 28 Sections of these Specifications, shall refer to the design professional as defined in the General Conditions and Supplementary Conditions.
- D. Provide cutting and patching required for installation as specified under other Sections. All patching shall maintain the rating of the wall or floor where it occurs.
- E. All equipment shall be installed in accordance with manufacturer's recommendations. Where conflicts occur between Contract Documents and these recommendations, a ruling shall be requested of the Design Professional.

1.06 COORDINATION

- A. Coordinate the Work specified in this Division under provisions of applicable Sections of Division 01.
- B. Drawings are diagrammatic in nature and shall not be scaled for exact locations. Take dimensions from architectural and structural Drawings and from actual measurements of each existing building and structure involved in the Work. Where not dimensioned or detailed, the Drawings indicate approximate locations and general arrangements of the Work. Not all junction boxes, pullboxes, fittings, risers, and conduit offsets are necessarily shown on Drawings; provide these as required by the conditions involved and by applicable codes for a correct and complete installation. If requested, location of any outlet, or device shall be revised up to 6 feet in any direction on the Drawings prior to rough-in with no change in price.
- C. Coordinate arrangement, mounting, and support of communications equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting pathways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

- D. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- E. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Sections.
- F. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 firestopping Sections.

PART 2 PRODUCTS

2.01 SEE APPROPRIATE SPECIFICATION SECTIONS FOR ALL PRODUCT-SPECIFIC INFORMATION.

- A. Products shall be from reputable, known, "Name Brand" manufacturers unless specific brand or models are specified.

PART 3 EXECUTION

3.01 TAMPER SWITCHES AND ALARM REPORTING

- A. Install tamper switches for all end devices, junction boxes, and panel enclosures. If the model selected for door position switches has tamper functionality it must be utilized. Unless noted otherwise, door position switches without built in functionality do not require tamper switches. This paragraph applies to Access Control, Video Surveillance, and Security Detection devices.
- B. If no tamper switch is available within the device itself, one must be provided and installed. Door position switches may be exempt, refer to paragraph above. Video Surveillance cameras with analytics-based tamper detection fulfill this requirement, no additional hardware is required.
- C. Configure tamper switches for immediate alarm and log entry during all system states, including during normal business hours.
- D. If a Security Detection intrusion alarm system is present, the access control system shall report all tamper conditions to the intrusion system. The intrusion system must report all tamper conditions from the access control system as immediate alarms during all system states, including during normal business hours. Coordinate with the building Owner to determine whether the alarm shall trigger an audible report or some other means of alert.

3.02 EXAMINATION

- A. Examine substrates, backings, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
- D. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.
 - 1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
 - 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- E. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- F. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 SYSTEM INTEGRATION

- A. Integrate all division 28 systems. See specific information from each section.
- B. Coordinate with other Electronic Safety and Security work to be included but not listed in Division 28 or indicated on the Security or Fire Alarm documents.
- C. Utilize only secure connectivity for all data transmissions. For example, any web interface must utilize a https protocol, not http.
- D. Upgrade all component firmware and software to latest stable version.
- E. Change the default login and password to unique combinations. Coordinate with Owner and give them all logins and passwords available.
- F. Disable unused services ports and protocols. If Owner IT department is responsible for switch and/or firewall configuration, give them a list of all utilized IP addresses, ports, etc. for configuration.

3.04 WIRING INSTALLATION

- A. Wiring Method: Install wiring in metal raceways according to Section 270500 "Common Work Results" Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Wiring Method: Install wiring in metal raceways except in accessible indoor ceiling spaces and interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- C. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.05 GROUNDING

- A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
- B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide [5] -ohm ground. Measure, record, and report ground resistance.
- D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 270526 "Grounding and Bonding for Communications Systems."

3.06 IDENTIFICATION

- A. Label each cable/wire pair within 1 foot of termination at device, controlling unit or head end, and any intermediate device along that overall path.

3.07 FIELD QUALITY CONTROL

- A. Testing:
 - 1. After installation, align, adjust, and balance system and perform complete testing to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
 - 2. Provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to tests.

- B. Test the physical operation all tamper detection and that it is consistently detected in the software / reporting functions.
- C. Confirm all recording logs are functional and configured to capture all activity from all users.

3.08 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION

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SECTION 28 46 22
DIGITAL ADDRESSABLE FIRE SYSTEM

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Fire-alarm control unit.
 - 2. Manual stations.
 - 3. System smoke detectors.
 - 4. Heat detectors.
 - 5. Carbon monoxide detectors.
 - 6. Notification appliances.
 - 7. Elevator Recall.
 - 8. Magnetic door holders.
 - 9. Remote annunciator.
 - 10. Addressable interface device.
 - 11. Digital alarm communicator transmitter.
 - 12. Network communications.
 - 13. Device guards.

1.02 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.
- F. VESDA: Very Early Smoke-Detection Apparatus.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
 - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, and electrical characteristics.
- B. Shop Drawings: For fire-alarm system.
 - 1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - 2. Include plans, elevations, sections, details, and attachments to other work.
 - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
 - 4. Detail assembly and support requirements.
 - 5. Include voltage drop calculations for notification-appliance circuits.
 - 6. Include battery-size calculations.
 - 7. Include input/output matrix.
 - 8. Include performance parameters and installation details for each detector.
 - 9. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - 10. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
- C. Specification compliance review.
- D. General Submittal Requirements:
 - 1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.

2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. Licensed or certified by authorities having jurisdiction.
- E. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
 2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
 3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
 1. In addition to items required by AHJ provide the following:
 - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
 - d. Riser diagram.
 - e. Device addresses.
 - f. Record copy of site-specific software.
 - g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
 - h. Manufacturer's required maintenance related to system warranty requirements.
 - i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.
- B. Software and Firmware Operational Documentation:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.05 MAINTENANCE MATERIAL SUBMITTALS

- A. MAINTENANCE MATERIAL SUBMITTALS
 1. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - a. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
 - b. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.

- c. Smoke Detectors, Fire Detectors[, and Flame Detectors]: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
- d. Detector Bases: Quantity equal to [two] percent of amount of each type installed, but no fewer than one unit of each type.
- e. Keys and Tools: One extra set for access to locked or tamperproofed components.
- f. Audible and Visual Notification Appliances: 1 of each type installed.
- g. Fuses: 2 of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
- h. Filters for Air-Sampling Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

1.07 PROJECT CONDITIONS

- A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction. Replace detectors used during construction at the completion of construction.

1.08 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
 - 2. Warranty Period: 5 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
- B. Noncoded, FM Global placarded addressable system, with multiplexed signal transmission.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 MANUFACTURERS

- A. Siemens
- B. Simplex (JCI)
- C. Notifier (Honeywell)
- D. Edwards

2.03 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
 - 1. Manual stations.
 - 2. Smoke detectors.
 - 3. Heat detectors.
 - 4. Duct smoke detectors.
 - 5. Carbon monoxide detectors.
 - 6. Automatic sprinkler system water flow.
 - 7. Fire-extinguishing system operation.

8. Fire standpipe system.
- B. Fire-alarm signal shall initiate the following actions:
 1. Continuously operate alarm notification appliances.
 2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciator.
 3. Transmit an alarm signal to the remote alarm receiving station.
 4. Unlock electric door locks in designated egress paths.
 5. Release fire and smoke doors held open by magnetic door holders.
 6. Activate voice/alarm communication system.
 7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 9. Recall elevators to primary or alternate recall floors.
 10. Activate elevator power shunt trip.
 11. Activate emergency lighting control.
 12. Activate emergency shutoffs for gas and fuel supplies.
 13. Record events in the system memory.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
 1. Valve supervisory switch.
 2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
 3. Elevator shunt-trip supervision.
 4. Independent fire-detection and -suppression systems.
 5. User disabling of zones or individual devices.
 6. Loss of communication with any panel or component on the network.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
 1. Open circuits, shorts, and grounds in designated circuits.
 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
 4. Loss of primary power at fire-alarm control unit.
 5. Ground or a single break in internal circuits of fire-alarm control unit.
 6. Abnormal ac voltage at fire-alarm control unit.
 7. Break in standby battery circuitry.
 8. Failure of battery charging.
 9. Abnormal position of any switch at fire-alarm control unit or annunciator.
 10. Voice signal amplifier failure.
- E. System Supervisory Signal Actions:
 1. Initiate local alarm.
 2. Identify specific device initiating the event at fire-alarm control unit[and remote annunciators.
 3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
 4. Transmit system status to building management system.
 5. Display system status on graphic annunciator.

2.04 FIRE ALARM CONTROL UNIT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Siemens
 2. Simplex (JCI)
 3. Notifier (Honeywell)
 4. Edwards
- B. General Requirements for Fire Alarm Control Panel

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
 - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder and printer .
 - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
 - d. The FACP shall be listed for connection to a central-station signaling system service.
 - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 1. Annunciator and Display: Liquid-crystal type, 40 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
 1. Pathway Class Designations: NFPA 72, Class B.
 2. Install no more than 99 addressable devices on each signaling-line circuit.
- E. Smoke Alarm Verification.
 1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
 2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
 3. Sound general alarm if the alarm is verified.
 4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- F. Notification Appliance Circuit
 1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
 2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
 3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- G. Elevator Recall:
 1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:
 - a. Elevator lobby detectors except the lobby detector on the designated floor.
 - b. Smoke detector in elevator machine room.
 - c. Smoke detectors in elevator hoistway.
 2. Elevator controller shall be programmed to move the cars to the alternate recall floor if the lobby detectors located on the designated recall floors are activated.
 3. Water-flow alarm connected to sprinklers in an elevator shaft and elevator machine room shall shut down elevators associated with the location without a time delay.
 - a. Water-flow switches associated with the sprinklers in the elevator pit may have a delay to allow elevators to move to the designated floor.

- H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.
- I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer
- J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- K. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.
 - 1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
 - a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
 - b. Programmable tone and message sequence selection.
 - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
 - d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.
 - 2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
 - 3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
- L. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
 - 1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- M. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- N. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
 - 1. Alarm current draw of entire fire alarm system shall not exceed 80 percent of the power supply module rating.
- O. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
 - 1. Batteries: Sealed, valve-regulated, recombinant lead acid size to operate without an emergency generator.
- P. Instructions: Computer printout of instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions

2.05 MANUAL FIRE-ALARM BOXES

- A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
 - 1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 - 2. Station Reset: Key- or wrench-operated switch.
 - 3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

2.06 SYSTEM SMOKE DETECTORS

- A. General Requirements for System Smoke Detectors:
 - 1. Comply with UL 268; operating at 24-V dc, nominal.
 - 2. Detectors shall be two-wire type.
 - 3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - 4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 5. Integral Visual-Indicating Light: LED type, indicating detector has operated.
 - 6. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition[and individually adjustable for sensitivity by fire-alarm control unit].
- B. Photoelectric Smoke Detectors:
 - 1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 - 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
- C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
 - 1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 - 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
 - 3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
 - 4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

2.07 CARBON MONOXIDE DETECTORS

- A. General: Carbon monoxide detector listed for connection to fire-alarm system.
 - 1. Mounting: Adapter plate for outlet box mounting.
 - 2. Testable by introducing test carbon monoxide into the sensing cell.
 - 3. Detector shall provide alarm contacts and trouble contacts.

4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

2.08 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
 1. Temperature sensors shall test for and communicate the sensitivity range of the device.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.09 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
- B. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
 1. Rated Light Output:
 - a. Cd as selected by manufacturer for space.
 - b. 15/30/75/110 cd, selectable in the field.
 2. Mounting: Wall mounted unless otherwise indicated.
 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 4. Flashing shall be in a temporal pattern, synchronized with other units.
 5. Strobe Leads: Factory connected to screw terminals.
 6. Mounting Faceplate: Factory finished, [red] [white].
- C. Voice/Tone Notification Appliances:
 1. Comply with UL 1480.
 2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
 3. High-Range Units: Rated 2 to 15 W.
 4. Low-Range Units: Rated 1 to 2 W.
 5. Mounting: [Flush] [semirecessed] [or] [surface mounted].
 6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.10 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
 1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 3. Rating: 24-V ac or dc.
- B. Material and Finish: Match door hardware.

2.11 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: [Flush] [Surface] cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.12 ADDRESSABLE INTERFACE DEVICE

- A. General:
 1. Include address-setting means on the module.
 2. Store an internal identifying code for control panel use to identify the module type.
 3. Listed for controlling HVAC fan motor controllers.
- B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate recall or shunt trip unit for power shut down.
 1. Allow the control panel to switch the relay contacts on command.
 2. Have a minimum of two normally open and two normally closed contacts available for field wiring.
- D. Control Module:
 1. Operate notification devices.
 2. Operate solenoids for use in sprinkler service.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture [one] [two] telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 1. Verification that both telephone lines are available.
 2. Programming device.
 3. LED display.
 4. Manual test report function and manual transmission clear indication.
 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
 1. Address of the alarm-initiating device.
 2. Address of supervisory signal.
 3. Address of trouble-initiating device.
 4. Loss of AC supply.
 5. Loss of power.
 6. Low battery
 7. Abnormal test signal
 8. Communication bus failure.

2.14 NETWORK COMMUNICATIONS

- A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.
- B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

- C. Provide integration gateway using BACnet or Modbus for connection to building automation system as required by BAS.

2.15 DEVICE GUARDS

- A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
 - 1. Factory fabricated and furnished by device manufacturer.
 - 2. Finish: Paint of color to match the protected device

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
 - 1. Devices placed in service before all other trades have completed cleanup shall be replaced.
 - 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
- C. Manual Fire-Alarm Boxes:
 - 1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
 - 2. Mount manual fire-alarm box on a background of a contrasting color.
 - 3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- D. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- E. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.
 - 1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
 - 2. Install a duct smoke detector and associated control module for AHU shutdown at each air handling unit 2000CFM or greater. Locate smoke detectors in the supply and return ducts per NFPA 72.
- F. Provide smoke detection at each smoke damper or control smoke damper with corridor detection when present. Coordinate locations of smoke dampers with mechanical contractor. Control per current adopted codes.
- G. Carbon Monoxide Detectors: Install as indicated on drawings and in locations where combustion occurs as required by the NEC and IBC.

- H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.
- I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
- J. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.
- L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.03 PATHWAYS

- A. Pathways shall be installed in EMT.
- B. Exposed EMT shall be painted red enamel in unfinished spaces. Installation of exposed raceways shall be approved by architect/engineer and painted to match wall or ceiling surface.

3.04 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with a supervised interface device to devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

3.05 IDENTIFICATION

- A. Install framed instructions in a location visible from fire-alarm control unit.

3.06 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.07 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

- F. Prepare test and inspection reports.

3.08 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 3. Perform test per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA72.

3.09 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for 2 years.

3.10 DEMONSTRATION

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

END OF SECTION

**SECTION 31 31 16
CHEMICAL SOIL TREATMENT**

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SECTION INCLUDES

- A. Chemical soil treatment.

1.03 RELATED SECTIONS

- A. Section 03 30 00 - Cast-in-Place Concrete

1.04 SUBMITTALS

- A. Submit in conformance with Section {id\#1000024} - {t\#1000024}.
- B. Product Data: Indicate toxicants to be used, composition by percentage, dilution schedule, intended application rate.
 - 1. For each type of termite control product indicated. Include EPA-Registered Label for termiticide products.
- C. Test Reports: Submit termite-resistant sheet manufacturer's summary of independent laboratory and field testing for effectiveness in subterranean termite exclusion.
- D. Manufacturer's Certificate: Certify that toxicants meet or exceed specified requirements.
- E. Certificate of compliance from authority having jurisdiction indicating approval of toxicants.
- F. Record and document 1) Date and time of application, 2) Moisture content of soil before application, 3) Termiticide brand name and manufacturer, 4) Quantity of undiluted termiticide used, 5) Dilutions, methods, volumes used, and rates of application, 6) Areas of application, and 7) Water source for application
- G. Warranty: Submit warranty at closeout.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing this type of work and:
 - 1. Having minimum of three (3) years documented experience.
 - 2. Approved by manufacturer of treatment materials.
 - 3. Licensed in Missouri.
- B. Regulatory Requirements: Formulate and apply termiticides according to the EPA-Registered Label.
- C. Source Limitations: Obtain termite control products from single source from single manufacturer.

1.06 PROJECT CONDITIONS

- A. Coordinate application of termiticide treatment of structure with access to all areas where termiticide is to be installed.

1.07 WARRANTY

- A. Soil Treatment Warranty: Manufacturer's standard form, 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.
 - 1. Warranty Period: Five (5) years from Date of Substantial Completion.

PART 2 PRODUCTS

2.01 CHEMICAL SOIL TREATMENT

- A. Termiticide: Provide an EPA-Registered termiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide

quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label.

1. EPA Title 7, United States Code, 136 through 136y approved; synthetically color dyed to permit visual identification of treated soil.
- B. Basis-of-Design Manufacturer/Products: Subject to compliance with the Contract Documents, available products that may be incorporated into the Work include, but are not limited to, the following manufacturers:
 1. Bayer Environmental Science Corporation: Premise® 75
 2. BASF Corporation : Termidor.
 3. Syngenta Professional Products : Altriset® Termiticide.
 4. FMC Corporation: Prevail.
 5. Nisus Corporation: BORA-CARE® Commercial Termiticide.
- C. Substitutions: See Section 01 60 00 - Product Requirements.
- D. Diluent: Recommended by toxicant manufacturer.
- E. Mixes: Mix toxicant to manufacturer's instructions.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label requirements, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

3.02 APPLICATION - CHEMICAL TREATMENT

- A. Comply with requirements of U.S. EPA and applicable state and local codes.
- 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 treatment evenly.
- C. Apply toxicant at following locations:
 1. Slabs-on-Grade: Treat soil below ground-supported slab-on-grade construction before the underslab vapor barrier is installed.
 2. Foundations: Treat soil along the entire inside perimeter of foundation walls; around both sides of interior partitions, around interior column footers; and along the entire outside perimeter from grade to the bottom of footing.
 3. Penetrations: Apply extra treatment around all building structure, plumbing pipes, electric conduit, etc. that will penetrate the floor slab.
- D. Under slabs, apply toxicant immediately prior to installation of vapor barrier.
- E. If inspection or testing identifies the presence of termites, re-treat soil and re-test.

3.03 PROTECTION

- A. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- B. 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.
- C. Post warning signs in areas of application.
- D. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

END OF SECTION

SECTION 32 31 19
DECORATIVE METAL FENCES AND GATES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Decorative aluminum fences.

1.02 RELATED REQUIREMENTS

- A. Section 03 30 00 - Cast-in-Place Concrete.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Shop Drawings:
 - 1. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.
- D. Samples: Submit two samples of fence panels, slat infill, [] inch ([] mm) by [] inch ([] mm) in size illustrating construction and colored finish.
- E. Manufacturer's Warranty.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum five years documented experience.

1.05 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Decorative Metal Fences and Gates:
 - 1. Knotwood, a brand of OmniMax International; []: www.knotwood.com/#sle.
 - 2. Substitutions: Not permitted.

2.02 FENCES

- A. Fences: Complete factory-fabricated system of posts and panels, accessories, fittings, and fasteners; finished with electrodeposition coating, and having the following performance characteristics:
- B. Electro-Deposition Coating: Multistage pretreatment/wash with zinc phosphate, followed by epoxy primer and acrylic topcoat.
 - 1. Total Coating Thickness: 2 mils (0.058 mm), minimum.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Set fence posts in accordance with the manufacturer recommended spacing.

- C. Space gate posts according to the manufacturers' drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected.
 - 1. Base type and quantity of gate hinges on the application, weight, height, and number of gate cycles.

3.03 TOLERANCES

- A. Maximum Variation From Plumb: 1/4 inch (6.3 mm).
- B. Maximum Offset From Indicated Position: 1 inch (25.4 mm).
- C. Minimum Distance from Property Line: 6 inches (152 mm).

3.04 CLEANING

- A. Clean jobsite of excess materials; scatter excess material from post hole excavations uniformly away from posts. Remove excess material if required.
- B. Clean fence with mild household detergent and clean water rinse well.

END OF SECTION

**SECTION 32 33 13
SITE BICYCLE RACKS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Exterior bicycle racks.

1.02 REFERENCE STANDARDS

- A. ASTM A312/A312M - Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Exterior Bicycle Racks:
 - 1. American Bicycle Security Company; []: www.ameribike.com/#sle.
 - 2. Huntco Supply, LLC; []: www.huntco.com/#sle.
 - 3. SiteScapes, Inc; []: www.sitescapesonline.com/#sle.
 - 4. Substitutions: See Section 01 60 00 - Product Requirements.

2.02 BICYCLE RACKS

- A. Exterior Bicycle Racks: Device allows user-provided lock to simultaneously secure one wheel and part of the frame on each bicycle parked or racked.
 - 1. Style: Inverted horseshoe rack formed by one u-shaped bend of round pipe.
 - 2. Capacity: 16 bicycles.
 - 3. Mounting, Ground: In-ground anchor.
 - 4. Finish: Satin brushed.
 - 5. Accessories: In-ground grout cover.
- B. Materials:
 - 1. Pipe: Stainless steel, ASTM A312/A312M, Type 304, Schedule 40S.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine surfaces to receive bicycle racks.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory conditions before proceeding.
- C. Do not begin installation until unsatisfactory conditions are corrected.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install level, plumb, square, and correctly located as indicated on drawings.
- C. In-Ground Anchor Installation:
 - 1. Prepare holes in size according to manufacturer's instructions.
 - 2. Place anchoring bolts through the holes in pipe.
 - 3. Lower rack into holes, ensuring the bottom of lower bends are at least 1-1/2 inch (38 mm) from the ground.
 - 4. Place concrete.
 - 5. Level rack before concrete sets.
 - 6. Support until dry.

END OF SECTION

SECTION 311000

SITE CLEARING

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. Protecting existing vegetation to remain.
 - 2. Removing existing vegetation.
 - 3. Clearing and grubbing.
 - 4. Stripping and stockpiling topsoil.
 - 5. Removing above- and below-grade site improvements.
 - 6. Disconnecting, capping or sealing, and removing site utilities.
 - 7. Temporary erosion- and sedimentation-control measures.

1.3 DEFINITIONS

- A. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.
- D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.
- E. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 MATERIAL OWNERSHIP

- A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
 - 1. Use sufficiently detailed photographs or videotape.
 - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.
- B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 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. Utility Locator Service: Notify "One Call" for area where Project is located before site clearing.
- C. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
- D. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.
 - 6. Excavation or other digging unless otherwise indicated.
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- E. Do not direct vehicle or equipment exhaust towards protection zones.
- F. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.
- G. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly identify trees, shrubs, and other vegetation to remain. Flag each tree trunk at 54 inches above the ground.
- 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 erosion- and sedimentation-control Drawings and Storm Water Pollution Prevention Plan (SWPPP).
- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

- A. General: Protect trees and plants remaining on-site according to requirements on the Drawings.
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Landscape Architect.

3.4 EXISTING UTILITIES

- A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed.
 1. Arrange with utility companies to shut off indicated utilities.
- B. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- C. Excavate for and remove underground utilities indicated to be removed.

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, 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. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
 - 3. Use only hand methods for grubbing within protection zones.
 - 4. Chip removed tree branches and dispose of off-site.
- 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 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
 - 1. Limit height of topsoil stockpiles to 72 inches.
 - 2. Do not stockpile topsoil within protection zones.
 - 3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.

3.7 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and 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 along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
 - 2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

END OF SECTION 311000

SECTION 312000

EARTH MOVING

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. Preparing subgrades for slabs-on-grade, walks, and pavements.
 - 2. Excavating and backfilling for buildings and structures.
 - 3. Drainage course for concrete slabs-on-grade.
 - 4. Subbase course for concrete walks and pavements.
 - 5. Subbase course for asphalt paving.
 - 6. Subsurface drainage backfill for walls and trenches.
 - 7. Excavating and backfilling trenches for utilities and pits for buried utility structures.
- B. Related Sections:
 - 1. Section 033000 "Cast-in-Place Concrete" for granular course if placed over vapor retarder and beneath the slab-on-grade.
 - 2. Section 311000 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.

1.3 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
- G. Fill: Soil materials used to raise existing grades.
- H. 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.
- I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 SUBMITTALS

- A. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D 2487.
 - 2. Laboratory compaction curve according to ASTM D 698.

1.5 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving 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. Utility Locator Service: Notify "One Call" for area where Project is located before beginning earth moving operations.
- C. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Section 311000 "Site Clearing" are in place.
- D. Do not commence earth moving operations until plant-protection measures specified on the plans are in place.
- E. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.

6. Excavation or other digging unless otherwise indicated.
 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- F. Do not direct vehicle or equipment exhaust towards protection zones.
- G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GM, GC, SW, SM, and SC according to ASTM D 2487, in acceptable locations as directed in the Geotechnical Report for the Project; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter. Soil Classification Groups CL and CH according to ASTM D 2487 can be considered marginally satisfactory as directed in the Geotechnical Report for the Project. The following criteria shall apply to the low volume change (LVC) material placed below the building floor slabs.
1. Liquid Limit: <45.
 2. Plasticity Index: <23.
- C. Unsatisfactory Soils: Soil Classification Groups ML, OL, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
1. Unsatisfactory soils also include satisfactory soils not maintained to 0-4 percent above the optimum moisture content at time of compaction for clay soils with a liquid limit greater than 45 and within 2 percent of optimum moisture content at time of compaction for clay soils with a liquid limit less than 45.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.
- H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.

- I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve.
- J. Sand: ASTM C 33; fine aggregate.
- K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.

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 earth moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include

rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
 - a. 24 inches outside of concrete forms other than at footings.
 - b. 12 inches outside of concrete forms at footings.
 - c. 6 inches outside of minimum required dimensions of concrete cast against grade.
 - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
 - e. 6 inches beneath bottom of concrete slabs-on-grade.
 - f. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

3.4 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 1. Excavations for Footings and Foundations: Excavate to provide 24 inches low volume change material per the Geotechnical Report for the Project
 2. 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. Do not disturb bottom of excavations intended as bearing surfaces.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
 1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

3.5 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.6 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
 1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
 1. Clearance: 12 inches each side of pipe or conduit.

- C. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
 - 1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- D. Trenches in Tree- and Plant-Protection Zones:
 - 1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
 - 2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.

3.7 SUBGRADE INSPECTION

- A. Notify Geotechnical Engineer when excavations have reached required subgrade.
- B. If Geotechnical Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 25 tons 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 first direction. Limit vehicle speed to 3 mph.
 - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Engineer, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Geotechnical Engineer, without additional compensation.

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, with 28-day compressive strength of 3500 psi, may be used when approved by Structural Engineer.
 - 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Engineer.

3.9 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory 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 including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
 2. Surveying locations of underground utilities for Record Documents.
 3. Testing and inspecting 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.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.11 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. 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.
- C. Backfill voids with satisfactory soil while removing shoring and bracing.
- D. Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- E. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- F. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.12 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. 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 satisfactory soil material.
 3. Under steps and ramps, use satisfactory soil material.
 4. Under building slabs, use engineered fill.
 5. Under footings and foundations, use satisfactory soil material.

- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.13 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content for clay soils with a liquid limit less than 45 and 0-4 percent above optimum moisture content for clay soils with a liquid limit greater than 45.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content limits described above and is too wet to compact to specified dry unit weight.

3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches 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 soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry density according to ASTM D 698:
 - 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 8 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 - 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.
 - 3. For areas below landscaped surfaces, compact each layer of initial and final backfill soil material at 90 percent.

3.15 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of 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 Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 - 1. Turf or Unpaved Areas: Plus or minus 1 inch.
 - 2. Walks: Plus or minus 1 inch.
 - 3. Pavements: Plus or minus 1/2 inch.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.16 SUBBASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course under pavements and walks as follows:
 - 1. Place base course material over subbase course under hot-mix asphalt pavement.
 - 2. Shape subbase course to required crown elevations and cross-slope grades.
 - 3. Place subbase course 6 inches or less in compacted thickness in a single layer.
 - 4. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry density according to ASTM D 698.

3.17 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Place drainage course 6 inches or less in compacted thickness in a single layer.
 - 2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry density according to ASTM D 698.

3.18 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 - 2. Determine that fill material and maximum lift thickness comply with requirements.
 - 3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
 - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.

3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.19 PROTECTION

- 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 become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

SECTION 321216

ASPHALT 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.

1.2 SUMMARY

- A. Section Includes:
 - 1. Hot-mix asphalt patching.
 - 2. Hot-mix asphalt paving.
 - 3. Pavement-marking paint.
- B. Related Sections:
 - 1. Section 312000 "Earth Moving" for aggregate subbase and base courses.

1.3 DEFINITION

- A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
 - 1. Job-Mix Designs: For each job mix proposed for the Work.

1.5 INFORMATIONAL SUBMITTALS

- A. Material Certificates: For each paving material, from manufacturer.
- B. Material Test Reports: For each paving material.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
 - 1. Prime Coat: Minimum surface temperature of 60 deg F.
 - 2. Tack Coat: Minimum surface temperature of 60 deg F.
 - 3. Slurry Coat: Comply with weather limitations in ASTM D 3910.
 - 4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. General: Use materials and gradations that have performed satisfactorily in previous installations.
- B. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- C. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
 - 1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: AASHTO M 320 or AASHTO MP 1a, PG 64-22.

2.3 AUXILIARY MATERIALS

- A. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes.
 - 1. Color: As indicated on the plans.

2.4 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by KDPT and designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types."
 - 1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
 - 2. Provide mixes complying with composition, grading, and tolerance requirements in ASTM D 3515 for the following nominal, maximum aggregate sizes:
 - a. Base Course: 1-1/2 inch.
 - b. Surface Course: 3/4 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to begin paving.
- B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment 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 first direction. Limit vehicle speed to 3 mph.
 - 2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 25 tons.
 - 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.

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. 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.
 - 1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 - 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- C. 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 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

3.4 HOT-MIX ASPHALT 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. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
 - 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
 - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 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. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
 - 3. Offset transverse joints, in successive courses, a minimum of 24 inches.
 - 4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
 - 5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
 - 6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.6 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 with 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. Correct laydown and rolling operations to comply with requirements.
- C. 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:
 1. Average Density: 97 percent of reference laboratory density according to ASTM D 6926 for surface course, and 95 percent of reference laboratory density for base course.
- 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. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 INSTALLATION TOLERANCES

- A. Pavement 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. Pavement 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: 1/4 inch.
 2. Surface Course: 1/8 inch.

3.8 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Allow paving to age for 7 days 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.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.
 - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
 - a. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- E. Replace and compact hot-mix asphalt where core tests were taken.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.10 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.
 - 1. Do not allow milled materials to accumulate on-site.

END OF SECTION 321216

SECTION 321313
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.

1.2 SUMMARY

- A. Section Includes:
 - 1. Driveways.
 - 2. Parking lots.
 - 3. Curbs and gutters.
 - 4. Walks.
- B. Related Sections:
 - 1. Section 033000 "Cast-in-Place Concrete for general building applications of concrete.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Other Action Submittals:
 - 1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified ready-mix concrete manufacturer.
- B. Material Certificates: For the following, from manufacturer:
 - 1. Cementitious materials.
 - 2. Admixtures.
 - 3. Curing compounds.

- C. Material Test Reports: For each of the following:
 - 1. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

1.6 QUALITY ASSURANCE

- A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
- B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
 - 1. Personnel conducting field tests shall be qualified as ACI Concrete Field-Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
- C. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.
- D. ACI Publications: Comply with ACI 301 unless otherwise indicated.

1.7 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

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, and smooth exposed surfaces.
 - 1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

- A. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.
- B. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 deformed bars.

- C. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 plain-steel bars; zinc coated (galvanized) after fabrication according to ASTM A 767/A 767M, Class I coating. Cut bars true to length with ends square and free of burrs.
- D. Epoxy-Coated, Joint Dowel Bars: ASTM A 775/A 775M; with ASTM A 615/A 615M, Grade 60, plain-steel bars.
- E. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.
- F. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
 - 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
 - 2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.
- G. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.
- H. Zinc Repair Material: ASTM A 780.

2.3 CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:
 - 1. Portland Cement: ASTM C 150, gray portland cement Type I/II.
- B. Normal-Weight Aggregates: ASTM C 33, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.
 - 1. Maximum Coarse-Aggregate Size: 1 inch nominal.
 - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- C. Water: Potable and complying with ASTM C 94/C 94M.
- D. Air-Entraining Admixture: ASTM C 260.
- E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
 - 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
 - 2. Retarding Admixture: ASTM C 494/C 494M, Type B.
 - 3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
 - 4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
 - 5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
 - 6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.4 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. dry.
- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.

2.5 RELATED MATERIALS

- A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork in preformed strips.

2.6 DETECTABLE WARNING MATERIALS

- A. Detectable Warning Paver Bricks: Materials shall be per the City of Lee's Summit specifications and standard details.

2.7 PAVEMENT MARKINGS

- A. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes.
 - 1. Color: As indicated on the plans.

2.8 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
 - 2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that meet or exceed requirements.
- B. Proportion mixtures to provide normal-weight concrete with the following properties:
 - 1. Compressive Strength (28 Days): 4000.
 - 2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
 - 3. Slump Limit: 4 inches, plus or minus 1 inch.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
 - 1. Air Content: 4-1/2 percent plus or minus 1.5 percent for 1-1/2-inch nominal maximum aggregate size.
 - 2. Air Content: 4-1/2 percent plus or minus 1.5 percent for 1-inch nominal maximum aggregate size.

3. Air Content: 5 percent plus or minus 1.5 percent for 3/4-inch nominal maximum aggregate size.
- D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

2.9 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Furnish batch certificates for each batch discharged and used in the Work.
 1. When air temperature is between 85 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.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
 1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
 2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 25 tons.
 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch according to requirements in Section 312000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded wire reinforcement 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.
- E. Epoxy-Coated Reinforcement: Use epoxy-coated steel wire ties to fasten epoxy-coated reinforcement. Repair cut and damaged epoxy coatings with epoxy repair coating according to ASTM D 3963/D 3963M.

3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 - 2. Provide tie bars at sides of paving strips where indicated.
 - 3. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
 - 1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
 - 2. Extend joint fillers full width and depth of joint.
 - 3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
 - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

- D. Control Joints: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
 - 1. 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.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
- E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- F. Consolidate concrete according to ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.
- G. Screed paving surface with a straightedge and strike off.
- H. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- I. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.
- J. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
 - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

- K. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
 - 1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow.
 - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
- L. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
 - 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 - 2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 - 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. 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. Refloat surface immediately to uniform granular texture.
 - 1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

3.8 DETECTABLE WARNINGS

- A. Blockouts: Form blockouts in concrete for installation of detectable paving units specified in City of Lee's Summit standard details.
 - 1. Tolerance for Opening Size: Plus 1/4 inch, no minus

3.9 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. 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 before and during finishing

operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by moisture curing 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.

3.10 PAVING TOLERANCES

- A. Comply with tolerances in ACI 117 and as follows:
 - 1. Elevation: 3/4 inch.
 - 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
 - 3. Surface: Gap below 10-foot-long, unleveled straightedge not to exceed 1/2 inch.
 - 4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
 - 5. Lateral Alignment and Spacing of Dowels: 1 inch.
 - 6. Vertical Alignment of Dowels: 1/4 inch.
 - 7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
 - 8. Joint Spacing: 3 inches.
 - 9. Contraction Joint Depth: Plus 1/4 inch, no minus.
 - 10. Joint Width: Plus 1/8 inch, no minus.

3.11 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Allow concrete paving to cure for a minimum of 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 markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.12 FIELD QUALITY CONTROL

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

- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
 - 1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. or fraction thereof of each concrete mixture placed each day.
 - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 - 2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 - 3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - 4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F and below and when it is 80 deg F and above, and one test for each composite sample.
 - 5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
 - 6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
 - a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
- D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
- F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- G. Concrete paving will be considered defective if it does not pass tests and inspections.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- I. Prepare test and inspection reports.

3.13 REPAIRS AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.
- C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 334100

STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipe and fittings.
 - 2. Junction boxes.
 - 3. Stormwater inlets.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Manholes: Include plans, elevations, sections, details, frames, and covers.
 - 2. Catch basins and stormwater inlets. Include plans, elevations, sections, details, frames, covers, and grates.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of pipe and fitting, from manufacturer.
- B. Field quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle manholes according to manufacturer's written rigging instructions.
- D. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 PE PIPE AND FITTINGS

- A. Corrugated PE Pipe and Fittings NPS 12 to NPS 60: AASHTO M 294M, Type S, with smooth waterway for coupling joints.
 - 1. Soil tight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.2 JUNCTION BOXES

- A. Designed Precast Concrete Catch Basins: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated on the plans, with provision for joint sealants.
 - 1. Joint Sealants: ASTM C 990, bitumen, or butyl rubber.
 - 2. Steps: Individual FRP steps, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of junction box to finished grade is less than 60 inches.
 - 3. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

2.3 STORMWATER INLETS

- A. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to plans.
- B. Grate Inlets: Made with horizontal grate opening, of materials and dimensions according to plans. Include heavy-duty frames and grates.
- C. Area Inlets: Made with vertical openings, of materials and dimensions according to plans. Include heavy-duty frames and grates.
- D. Frames and Grates: Heavy duty, according to plans.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install junction boxes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of micro tunneling.
- F. Install gravity-flow, nonpressure drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow.
 - 2. Install piping with 18-inch minimum cover.
 - 3. Install PE corrugated sewer piping according to ASTM D 2321.

3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure drainage piping according to the following:
 - 1. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
 - 2. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 JUNCTION BOX INSTALLATION

- A. Construct junction boxes to sizes and shapes indicated.
- B. Set frames and covers to elevations indicated.

3.5 STORMWATER INLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
- B. Install outlets that spill onto grade, anchored with concrete, where indicated.
- C. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
- D. Construct energy dissipaters at outlets, as indicated.

3.6 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318.

3.7 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Section 221413 "Facility Storm Drainage Piping."

- B. Make connections to existing piping and underground manholes.
 - 1. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.8 IDENTIFICATION

- A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
 - 1. Use warning tape or detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.9 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate reports for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 - 3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
 - 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.
 - 2. Test completed piping systems according to requirements of authorities having jurisdiction.
 - 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 - 4. Submit separate report for each test.
 - 5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Exception: Piping with soil tight joints unless required by authorities having jurisdiction.
 - b. Option: Test plastic piping according to ASTM F 1417.

3.10 CLEANING

- A. Clean interior of piping of dirt and superfluous materials

END OF SECTION 334100